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April – June 1950

Quarterly Journal

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The American Congress on Surveying and Mapping is a non-profit association, organized to advance the sciences of surveying and mapping in their several branches, in furtherance of the public welfare and in the interests of both those who use maps and surveys and those who make them. It aims to establish a central source of reference and union for its members, to contribute to public education in the use of surveys and maps, and to encourage the prosecution of basic surveying and mapping programs, especially those programs which are paid for, in whole or in part, with public funds.

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Tenth Anniversary Meeting

June 21, 22, and 23, 1950, Shoreham Hotel Washington, D.C.

A BROAD PROGRAM of professional interest to all those concerned with the varied activities of the American Congress on Surveying and Mapping has been scheduled to culminate 10 years of successful operation, growth, and development.

The international aspect of the Congress will be highlighted at the opening session on June 21, through the presentation and remarks of high public officials from eight foreign governments.

In addition to the formal papers and discussions, an elaborate exhibit of surveying and engineering equipment, materials, and supplies, the most extensive display ever to be sponsored by the American Congress, will include both domestic and foreign manufacture.

To all concerned with the advancement of the profession, the American Congress on Surveying and Mapping extends a most cordial invitation to attend the Tenth Anniversary Meeting.

Please refer to the "Preliminary Program," which you have received, for detailed information and instructions. If you have not already forwarded your registration, please make your last-minute preparations now. Reservations will be accepted by the Shoreham Hotel.

April • May • June • 1950

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Admiral Colbert Retires From Coast and Geodetic Survey

IN A CEREMONY befitting the occasion, Rear Admiral Leo Otis Colbert retired from the United States Coast and Geodetic Survey on April 7, 1950, after serving with the Bureau continuously for 42 years. The large auditorium of the Department of Commerce, where the exercises were held, was filled with friends and associates of Admiral Colbert, who came to honor him and to wish him well on his last day of active service. The Secretary of Commerce, Charles Sawyer, lauded the work of Admiral Colbert as Director of the Survey for the past 12 years and awarded him the Distinguished Service Ribbon for "exceptionally distinguished service to the Government of the United States while serving in a position of major responsibility, as Director, United States Coast and Geodetic Survey, during World War II."

During Admiral Colbert's long tour of duty in the Coast Survey, which goes back to 1907, he has filled many positions of responsibility both in the field and in the Washington Office. Among these were command of a number of the major survey ships of the Bureau; Director of Surveys in the Philippines; Chief of the Section of Vessels and Equipment; Chief of the Division of Charts; and finally, Director of the Bureau in 1938. Admiral Colbert was instrumental in improving the wire-drag method of locating submerged pinnacle rocks. In the early thirties he was engaged in a comprehensive survey of the important Georges Bank, utilizing for the first time special control methods for accurately tying in this distant Bank with the coastal triangulation.

The American Congress on Surveying and Mapping has more than ordinary cause to participate in honoring Admiral Colbert, not only for the significant contributions he has made in the fields of activity in which the Congress is interested, but for his part in establishing and sustaining the organization, of which he is a charter member. His sympathetic understanding of the aims and purposes of the Congress and the national benefits to be derived from the successful functioning of such an organization is exemplified in his keynote address at the Sixth Annual Meeting of the Congress, of which the following are extracts:

"The American Congress on Surveying and Mapping was organized after very careful consideration. Its formation was in response to a long-felt need, expressed by many individuals—among whom were prominent educators, practicing surveyors, and government officials—for a national body that would effectively represent and promote the interests of surveying and mapping . . .

"The American Congress on Surveying and Mapping is the logical body to crystallize an appropriate sentiment throughout the country for the development of planned programs for surveying and mapping . . .

"The Congress deserves the active support and encouragement of all federal mapping agencies, and of all other groups and individuals interested in advancing the sciences of surveying and mapping. Judged by ordinary standards the possibilities of the Congress are almost without limit and in due time can well become the most potent single body influencing the development of basic mapping programs in the country—a matter in which every federal mapping agency is vitally interested."

It is the hope of the American Congress on Surveying and Mapping that Admiral Colbert will for many years continue to give to the Congress the benefits of his wise counsel and his broad organizational experience.

—A. L. SHALOWITZ

REAR ADMIRAL LEO OTIS COLBERT

Operational Geodesy in Latin America

By COLONEL FREMONT S. TANDY

DIRECTOR, INTER-AMERICAN GEODETIC SURVEY, BALBOA HEIGHTS, CANAL ZONE

AS YOU KNOW, President Truman recently emphasized the necessity for making our scientific knowledge and technical procedures available to others. Adequate maps and charts, I am sure you will agree, provide essential information required for all economic or social development programs.

A serious lack of maps in Latin America has limited, and may forestall, many worthwhile programs. Our neighbors there urgently need our assistance in their cartographic work.

You are no doubt familiar with the two programs of assistance being carried on by the Institute of Inter-American Affairs, and by the Inter-Departmental Committee on Scientific and Cultural Cooperation.

In addition, a mapping and charting program has been in effect in Latin America for 3 years. Very few here have heard previously of this unusual and far-reaching cartographic endeavor which is being executed by elements of the National Military Establishment in coordination with our Department of State.

It is my purpose to describe mainly the geodetic elements of this bilateral cartographic effort which is international in scope and collaborative or cooperative in execution.

In order to insure the fullest cooperation possible, and to obtain uniformity of results, the objectives and specifications of the Pan American Institute of Geography and History, an agency of the Organization of American States, have been followed closely. This agency has been responsible in large measure for the rapidity with which the work was implemented and for the success achieved to date.

Among the logical and long-range objectives towards which the Commission on Cartography of the Pan American Institute of Geography and History has worked for many years, as many of you are aware, are the following: (1) to establish, integrate and connect the existing systems of geodetic control; (2) to develop therefrom a continental datum for South America; (3) to connect with the North American Datum; and (4) to finally produce accurate maps and charts in accordance with common specifications.

Collaborating countries include most members of the Organization of American States, as well as British, French, and Dutch Colonial Governments.

Agencies of the United States which are directly engaged in the cartographic work in Latin America of which I speak are: the Air Force, which is executing much of the aerial photography required; the Inter-American Geodetic Survey, which is engaged in geodetic and related work; and the Navy, which is engaged in coastal photography and the production of hydrographic charts.

The substantial support of the Coast and Geodetic Survey has contributed most materially to our geodetic work; and the Geological Survey, in its work of geological exploration, is contributing to the program indirectly.

Presented at Ninth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 8–10, 1949.

By way of explanation, the Inter-American Survey is fundamentally a civilian technical organization under the direction of officers of the U.S. Corps of Engineers. This organization serves as a central planning and coordinating agency for all geodetic survey operations undertaken in connection with the collaborative programs. It makes material assistance available to other Amerian States by the following methods: (1) furnishing consulting geodetic personnel; (2) lending geodetic, radio communication and transportation equipment; (3) training of personnel in the field; and (4) executing geodetic work which is beyond the present capabilities of the various countries.

SYSTEMS OF GEODETIC CONTROL REQUIRED

When the work was initiated, many problems arose immediately. No agency had full knowledge of the amount and precision of the geodetic work previously accomplished, nor the work which would have to be undertaken to provide the the minimum required number of fundamental systems of geodetic control. Initially, the task seemed formidable; the undertaking ambitious.

It was found that none of the systems of control in Latin America were established on a common datum, nor enlaced with those in adjacent countries. In some instances, there were several datums in a particular country. The greatest lack found was in precise leveling which was practically nonexistent.

Another large problem was the changing of procedures and methods to conform to standards acceptable to all. In several instances, the French and German methods of geodetic surveying were being employed. In others, the specifications and methods of the U.S. Coast and Geodetic Survey were gradually being adopted.

With the technical leadership provided by United States agencies; by demonstrations of our methods and procedures; and, by training, either in the field or in our various institutions in the United States, the problems of establishing standard methods and procedures and of following standard specifications have been overcome in practically every instance of collaborative work.

It was determined after much study that the bare minimum number of horizontal systems of control sufficient to meet initial requirements were: (1) a first order scheme extending from the United States throughout Central America to Colombia; (2) a peripheral loop around South America with a minimum number of transcontinental ties; and (3) a connection between the North and South American systems at the Panama-Colombia border.

To indicate the extensive geodetic effort required, the distance from Tapachula, Mexico, to the Panama Canal is approximately 1,200 miles. Thence to Colombia where a loop around South America would logically start, is somewhat over 300 miles. An arc southerly along the west coast of South America to Tierra del Fuego adds 5,700 miles. Continuation up the east coast of South America around the bulge of Brazil, across the Amazon River, and through Venezuela to close the loop is another 7,000 miles. Necessary transcontinental ties add upwards of 4,000 miles. In the Caribbean Archipelago, the arcs of the islands of Cuba and Hispaniola add another 1,500 miles, giving a grand total of projected or accomplished first-order triangulation of about 19,700 miles.

First-order level lines between tide-gaging stations and those covering first-order horizontal systems will be of even greater length.

Size alone does not depict all of the problems inherent in this project. A re-

lated consideration is the wide variation in physical and climatic conditions encountered. In Central America, we find high, active volcanoes and the malarial "mosquito coasts" of Honduras and Nicaragua, the temperate uplands of Guatemala, and high uninhabited mountains of Costa Rica, and the rain forests and swamps of Panama. In South America, we find all of these conditions repeated and enlarged. The deserts of Peru and Chile and the sub-arctic regions of southern Chile are added rugged conditions. The Andes, with their few passes (most of which are over 5,000 meters in altitude) impose a spectacular barrier; as also does, in a different way, the trackless Amazon valley.

The greatest problems are the extreme lack of access and communications and providing adequate medical care for personnel. Very few areas can be reached by the conventional transportation normally employed there. Practically every conceivable means of transportation has been employed, including native bearers, mule trains, ox-carts, dug-out canoes, army landing craft, the army "jeep" and 4-wheel drive trucks, helicopters, liaison aircraft and heavy transport aircraft.

The establishment of precise control under the diverse and adverse conditions encountered has taxed and will continue to tax the ingenuity, hardihood, and capabilities of the engineers of all nations.

Controlling and supplying an organization spread over an area of 18,000,000 square miles of land and water is fraught with numerous unique difficulties. Since we have already overcome many of these difficulties, I am confident that all obstacles, including the crossing of the Amazon River and the Andes, can and will be overcome.

Substantial progress has been made in field work in a short period of less than 3 years despite the necessity for establishing and training a large geodetic organization and reaching agreements as to the work to be done.

PROBLEMS OF TRIANGULATION

Our first, most difficult, and still continuing task is reconnaissance for first-order triangulation. In 3 years, a continuous scheme of first-order triangulation extending from Oaxaca, Mexico, to southern Chile, a distance of almost 7,000 miles, has been reconnoitered and nearly completely monumented.

From Bogota, Colombia, another arc extending easterly through Venezuela to Trinidad and a loop to the Orinoco River are nearly completely reconnoitered and monumented. Preliminary work on the arcs in Cuba and Hispaniola has been completed.

Of particular interest may be the fact that two tentative routes across the Amazon River Basin to complete the South American continental loop have been selected after aerial reconnaissance indicated the practicability of a connection between Brazil and Venezuela.

The extension of the North American Datum throughout Central America and the connection between the North and South American Datums are nearing completion. In South America and the Caribbean, observations on the first-order schemes are now extensively in progress.

It is interesting to note that the preliminary computations of geographic positions, when plotted on existing maps or charts, place in the Pacific Ocean some of our triangulation stations which are located on prominent peaks on the mainland. Many mountains have been found to be out of position by 10 to 20 miles or

more, and their altitudes in error by several thousand feet. A 5,000-foot range of mountains in Panama does not appear on most maps or charts in current use.

Base measurements have also progressed rapidly. Nine first-order bases in the Caribbean and eight in Central America have been measured. In South America, 16 bases have been completed, and 9 others are currently in progress.

The base measurement methods of the Coast and Geodetic Survey, employing the 50-meter invar tape, have been introduced, and have received the enthusiastic approval of the engineers of all collaborating countries despite initial skepticism and a desire to adhere to European practices. The speed and ease with which both rail and staked bases were prepared and measured have amazed our friends.

Requisite Laplace and other astronomic stations are being established along all arcs of first-order triangulation.

First priority in the vertical control work has been given to the instruction of local engineers, in order to initiate this relatively slow task in all areas simultaneously.

The installation of necessary tide gages and their connection by precise levels where feasible has been given high priority in order to establish required vertical datums.

It is interesting that an unforeseen impediment to rapid progress in leveling is the limitation on the length of level shot in tropical climates. Even the most thoroughly experienced observers have discovered that 60 meters, where terrain permits, is the maximum practicable length.

Atmospheric conditions have also seriously affected the progress of observational work. Contrary to expectation, the best observational weather in many areas occurs during the rainy season. Triangulation observations are frequently limited by a provokingly persistent water haze, as well as by clouds and smoke. Because of variable and unpredictable weather conditions, some triangulation stations have had to be occupied from 45 to 60 days. These ulcer-producing delays can be overcome only by persistence and pills.

INSTRUMENTS AND EQUIPMENT

The necessity for standardization was naturally a major consideration in the selection of equipment. Availability and suitability for use in the tropics were primary factors.

The first-order horizontal directional instrument adopted was the Wild T-3 theodolite having a least reading of 0.1″. This instrument has proven itself to be rugged, compact, and easy to manipulate. It is adequately precise, but requires factory repair. Its optical micrometer makes for unusual ease and rapidity of reading which greatly facilitates the training of new observers. This is one of its most important advantages.

For second and third-order triangulation, the smaller Wild T-2, which has all the essential desirable features of the T-3, except that its least reading is 1″, was adopted.

The U.S. Coast and Geodetic Survey-type precise level was adopted initially, and has been widely introduced into Latin America. Recently the Wild N-III precise level with modifications also has been adopted. Modifications necessary to permit its use with standard U.S. Coast and Geodetic Survey-type invar rods are being installed by the manufacturer. Experience thus far demonstrates this level to be capable of yielding first-order results.

Two types of instruments for astronomic observations are currently in use; namely, the familiar Bamberg broken-telescope transit, and the newer Wild T-4 universal theodolite. Extensive tests demonstrate the comparable accuracy of these two types.

SUPPLEMENTAL UNDERTAKINGS

At this juncture, it would be well to consider some of our supplemental undertakings.

Of great importance to the geodetic effort is the Inter-American Tide Gaging Program undertaken in collaboration with the Coast and Geodetic Survey. Each country with a sea outlet will have at least two primary stations. Those with extensive coast lines will have the number requisite for geodetic purposes.

The overall installation program envisages the establishment of an adequate number of primary tide-gage stations along both coasts of Central and South America, as well as in the Caribbean. Supplemental portable gages are also being installed. Data obtained from these gages will prove extremely useful for maritime purposes as well as for the geodetic purpose of determining mean sea level for which they were established.

A second activity which has been initiated recently is an extensive gravimetric survey. The first phase of this survey has been the establishment of pendulum-base gravity stations in selected locations to serve later as calibration points for more extensive work with the convenient and rapid gravimeter.

The principal purpose of the gravimetric work is to determine the deflection of the vertical at the selected origin for the South American Datum.

The gravimetric approach to the task of adjustment is a virtual necessity in South America. The scarcity of geodetic data eliminates the practicability of an adjustment of the kind employed to establish the North American Datum. A dense gravity survey around a carefully selected point of origin will give the data required to effect adjustments of the entire geodetic net.

Several possible points of origin are under study, but no definite selection has yet been made. Favorable sites can be found in the Llanos of Venezuela and in the pampas of Argentina. The Brazilians favor a position near Goiaz, Brazil.

The major problem affecting the selection of a suitable site is accessibility, and the rapidity with which the gravimetric survey can be accomplished. For an initial origin, a point in Argentina appears most desirable at this time.

Another project of somewhat greater cartographic than geodetic interest is the magnetic survey soon to be commenced. The proper use of topographic maps and aeronautic charts, particularly the latter, requires additional magnetic data.

While maintaining accepted standards and specifications, the Inter-American Geodetic Survey and the collaborating agencies have been quick to adopt any expedient or innovation in equipment, procedure or techniques which facilitates our work. A number of new departures have been thoroughly tested, and have proven advantageous.

AERIAL RECONNAISSANCE IMPORTANT

One outstanding improvement has been the use of aircraft in effecting reconnaissance, particularly in mountainous or jungle terrain with little access. The necessity for utilizing aircraft was forced upon us as reconnaissance commenced in Eastern Panama. Military airplanes of the C-45, C-47 and L-5 types were a-

vailable. Experimentation soon demonstrated that these types were satisfactory within the limitations imposed by their range and ceiling characteristics.

A unique reconnaissance method evolved is briefly as follows: An observer flying toward, and at the altitude of, a known selected station determines magnetic bearings to other visible stations. A likely station in the visible distance is selected, and the airplane flown over the known station directly toward the selected station. The course and speed of the airplane are recorded while the selected line is traversed. Upon arrival at the tentatively selected position, the line is again checked for visibility, and the reverse bearing obtained as a check. The altitude of the new station is determined by means of the airplane's altimeter and a hand level.

One side of the tentative figure having been proven, the other sides are established similarly. Internal angles of the figures are easily obtained from the bearings of the sides, and approximate strengths of figures can be easily obtained. Lengths of all lines are known approximately.

By this aerial reconnaissance method, as much as 100 miles of arc can be reconnoitered in a day. The results obtained in a few hours are comparable or better than those obtained in many weeks or months by ground reconnaissance.

New stations not readily identifiable either from the ground or air are marked by dropping a quantity of aluminum foil streamers of the kind commonly used for anti-radar purposes. Some of the streamers hang in the trees, and others, together with the cores, drop to the ground. The hilltops thus marked appear rather thoroughly festooned in silver.

This marking has been referred to facetiously as "Operation Christmas Tree." The considerable glitter of the aluminum foil in sunlight makes the stations conspicuous from the air and visible in some instances for appreciable distances from the ground. The foil and cores which fall through the trees serve to identify positively to the ground parties the stations selected.

Helicopters have been used in aerial reconnaissance with much success. The helicopter has the advantage of the ability to hover over stations so that the observer can take directions deliberately and carefully with a sextant or prismatic compass, thus improving the accuracy of the reconnaissance. Also, the heights of needed towers can be determined accurately by a weighted steel tape suspended from the helicopter. Accurate and rapid profiling of long lines in flat areas can be accomplished.

The helicopter has also proved invaluable in observing work by delivering to and picking up observing personnel from isolated stations; by supplying parties on stations, and by performing other extremely useful missions, particularly emergency rescues of injured or sick personnel.

The helicopter in its present stage of development is somewhat limited in ceiling and requires much maintenance. The helicopter and the reconnaissance airplane can be considered essential tools of the geodetic engineer.

In jungle terrain, it is impossible to establish much more than the bare minimum of control for the stereocompilation of maps. Most of the control which must be used consists of main arc triangulation stations because of the high cost of additional control. In jungle areas, if there is any extensive time lag between the execution of the control surveys and the aerial photography, the undergrowth will so obscure the stations that they cannot be identified on the photographs.

Marking panels of sheet aluminum foil are being utilized to assist in identification. These panels, forming 50-foot crosses with 10-foot arms, are quite durable; retain their high reflectivity for a long period of time; and are readily identifiable on the photographs. If required, special photographic flights are made shortly after the panels are placed so that a positive photographic record for identification is available.

INTERNATIONAL COOPERATION NECESSARY

The duration of this collaborative and incidental cooperative work depends, of course, upon the availability of support to include funds, personnel and equipment, both on the part of the United States and other collaborating countries.

The contributions of the collaborating countries have been continually increasing under the impetus of demonstrated values. On a comparable basis, these contributions amount to about 2 to 10 times the contributions of the United States.

The success of this program is directly attributable to the adoption of, or provision for, national cartographic programs, and accelerating them only to the extent necessary to assure their expeditious accomplishment by local technical personnel.

In general, the support from the United States as related to funds and equipment has been adequate; but as related to trained geodetic personnel has been deficient, requiring the establishment of training programs.

What I've said has been only a very brief summary of this extensive Latin-American endeavor. We take pride in our joint accomplishments which have been achieved despite many and varied difficulties.

I have not had time to tell you that, in overcoming our difficulties there have been many amusing incidents, such as the Brass insisting that we did not need our requested arctic clothing, yet on tropical mountain peaks our instruments have frozen beyond use and the observers fancied themselves only slightly displaced from the North Pole.

Of course, we peace-loving and law-abiding engineers have weathered our quota of revolutions and changes of government, yet our total casualties to date have been only three bullet holes in one jeep and one scared director.

As related to natural phenomena, we've been only slightly deterred by bolts of lightning which have precipitously displaced us from our stations of duty; or by volcanic disturbances and earthquakes which have convinced our personnel that they should postpone observations and attend the local fiestas in the valley towns below.

Of course, our boys are interested in flora and fauna, and, in reaching certain stations, have spent from 2 to 12 weeks in pursuit of their natural science hobbies while dodging charging wild pigs, side-stepping the dangerous fer-de-lance and bushmaster snakes, and avoiding the curious black cats and mountain lions.

Neither have I told you about an air-dropped case of rations impinging upon a native's cranium, nor of an air-dropped piece of pipe whistling past the ears of a startled young lieutenant.

In conclusion, I would like to point out that from this collaborative cartographic work many benefits will accrue to all participants. I know from personal experience that the Latin Americans earnestly desire to cooperate with the United States in this significant Inter-American technical endeavor.

We foresee the early extension of the North American Datum to South Amer-

ica; the ultimate completion of the peripheral loop around South America; the establishment of a South American Datum and its connection to the North American Datum; and the production of urgently needed maps and charts.

One interesting fact is that, before the completion of this program, there will exist a continuous adjusted arc of first-order triangulation from Alaska to southernmost Chile, which is believed the longest north-south and most southerly arc in existence. You can appreciate that this geodetic knowledge will be a significant contribution to science. It may shed light on such matters as the deflection of the vertical, and perhaps on the figure of the earth itself.

In my opinion, the establishment of fully connected and fundamental first and second-order systems of horizontal and vertical control, except for a connection between Venezuela and Brazil, can be realized within a very few years.

I believe that this program is most effectively implementing the objectives of the Rio de Janeiro and Bogota Conferences, as well as the announced national policy of the United States.

As a result of a carefully planned and coordinated effort, the leadership of its technical personnel, and the limited equipment temporarily provided, the United States is making an enduring and substantial contribution to the progress, development, and welfare of our Latin American friends and neighbors.

NSPE Wants an Engineer to Run Point 4

RECOMMENDING that a qualified engineer be appointed to head any plan to implement President Truman's Point 4 program, the National Society of Professional Engineers closed a four-day convention at Houston, Tex., Dec. 10.

During the meeting, the group presented an honorary scroll to a representative of former President Herbert Hoover for his "services to mankind."

The Point 4 recommendation, submitted by the organization's legislative committee, noted that Congress may act next year to implement the President's plan to export U. S. know-how to undeveloped areas of the world.

In accordance with a bill presented to Congress in the last session but never acted upon, the group urged that an Institute of International Technical Cooperation be established. The NSPE recommended that the head of this institute should be "either a highly qualified engineer or one who is experienced in administration of programs and projects involving large engineering aspects." It also recommended that there be an advisory body which should include adequate engineering representation. Strongest recommendation was that any program such as the President's Point 4 should be carried out "with the fullest utilization of the services of private agencies and persons."

A second legislative recommendation concerned a matter long battled over by the organization. This was the proposed extension of the federal social security law—a revised version of which was passed by the House in its last session and action on which is expected by the Senate. Of major interest is the provision to extend the social security system to the self-employed.

Although the group has long favored this move, it suggested that self-employed engineers be exempted from coverage on the same basis as are doctors and lawyers.—*Engineering News-Record*, December 22, 1949.

Photogrammetry as an Aid to Engineering

By GEORGE D. WHITMORE

CHIEF OF TECHNICAL STAFF, TOPOGRAPHIC DIV., U. S. GEOLOGICAL SURVEY

AS AN APPROPRIATE INTRODUCTION to the subject of photogrammetry as an aid to engineering, I should like first to devote a few moments to a brief explanation of how photogrammetry is used by the Geological Survey in its national topographic-mapping program.

Modern topographic mapping procedures may be considered as comprising three major phases. The first phase involves several preliminary operations, including basic specifications, the procurement of aerial photographs, and the running of control surveys of triangulation, traverse, bench-mark levels, and fourth-order elevations on picture points.

The second major phase is the preparation of the original map sheet, requiring both photogrammetric laboratory work and field surveys. Photogrammetry is used today, in one way or another, on all topographic quadrangle sheets prepared by the Survey. Where the terrain is quite flat, or gently rolling, and the contour interval small, photogrammetry is used only to prepare a detailed planimetric base sheet, on which the contours subsequently are plotted in the field by means of conventional planetable surveys. Where the terrain runs from hilly to mountainous, the entire map, including contours, is originally compiled in the photogrammetric office. The compilation sheet is afterwards taken to the field for what is called a field-completion survey. This involves investigations or surveys for all those features which do not appear in photographs. These include, to name but a few, place names and feature names, political subdivision boundaries and monuments, public-land subdivision corners, classification of roads and buildings, cemeteries, mines, springs, and features hidden from camera view in forest areas. All these and many other features of similar nature must be carefully investigated on the ground and plotted on the map sheet by means of planetable surveys. The field work at this time also includes certain accuracy-testing surveys, in order that there may be reasonable certainty that the maps are in fact complying with the official accuracy specifications.

The third major phase includes the map-finishing operations. This involves the separation of the various colors by either smooth drafting or engraving, followed by checking, map editing, and quantity reproduction by photolithography and offset press.

MAP-PLOTTING INSTRUMENTS

The principal photogrammetric map-plotting instrument used by the Geological Survey is known as the multiplex. A characteristic of this instrument is that the plotting scale of the original compilation varies in inverse proportion to the flying altitude, which in turn varies with the contour interval. For quadrangle map sheets, the compiling scale is always necessarily larger than the largest standard publication scale of 1:24,000. For example, a 20-foot-contour map being compiled by multiplex would usually require a plotting scale of 1:12,000, which in engineers' language is one inch equals 1,000 feet. If the

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contour interval is 10 feet, the plotting scale would be twice as large, or 1:6,000, which is one inch equals 500 feet. If the contour interval is 40 feet, the compiling scale theoretically would be in the neighborhood of 1:24,000, but because photographic airplanes so far have a relatively low altitude ceiling, the compiling scale for this interval, and all larger intervals, is ordinarily the convenient scale of 1:15,840, which is one inch equals 1,320 feet, or one inch equals exactly one-quarter mile. When airplanes can go higher, the plotting scale for 40-foot-contour maps will be reduced. Thus, up to this time, the multiplex photogrammetric procedure as used by the Survey has required the original sheets to be compiled at scales of 1:6,000, 1:12,000, or 1:15,840, but the final maps would be published at either 1:24,000 or 1:62,500 scale.

Research is continuously under way to develop simple plotting instruments of greater efficiency, which means, for any given contour interval, flying at higher altitudes and therefore using fewer photographs. For the multiplex type of instrument, this also means a smaller compiling scale.

ORIGINAL MAP SHEETS

In preparing the original large-scale compilation the photogrammetrists show many features and details which are not, by American tradition, suitable for publication. For instance, field fences and other types of field boundaries, small outbuildings, isolated trees, prominent rocks, and similar features which can be clearly seen in the photographs, are plotted on the original map sheet. These extra features are shown primarily to facilitate the subsequent planetable completion and checking surveys. The engineering profession has gradually become aware of the availability of these extra-large-scale originals and the fact that they often show a wealth of extra and unconventional map details. The result is an increasing demand for contact prints or photographic copies of the original compilations. It should be noted that the original sheets at compilation scale are not necessarily in compliance with standard accuracy specifications for horizontal position. They will be of standard accuracy in this regard, of course, when they are later reduced to the publication scale. With respect to horizontal accuracy, therefore, the originals should be regarded as enlargements of the published maps.

MAP-ACCURACY STANDARDS

Most of the present-day topographic maps of the Survey are made to comply with the national map-accuracy standards. These may be summarized in two brief statements: (1) that 90 percent of the contours on any map, or the elevations interpolated from the contours, shall be correct within one-half contour interval; and (2) that 90 percent of all well-defined planimetric features shall be plotted in correct location on the map sheet within 1/50th inch at publication scale. This horizontal accuracy requirement, translated into distance on the ground, means a radius of 40 feet in plotting tolerance for a 1:24,000-scale sheet, and 100 feet for a 1:62,500-scale sheet.

Topographic maps of these accuracy standards will meet most requirements of most map users, including engineers. On the other hand, maps of any significantly lower accuracy would fail to fulfill many important map users' needs, including many of the engineer users. Furthermore, maps having this degree of accuracy can be readily revised up to date at any time, whereas less accurate maps present many practical difficulties when revision is undertaken. Modern

photogrammetry makes economically feasible the preparation of maps to these standards. The only *large* areas in the United States where substandard maps would now be scheduled, for the reason that standard accuracy would be unduly difficult and costly, are the dense redwood and Douglas-fir forests on the West Coast.

EFFECT ON COSTS

For many decades the publication scale of 1:62,500 was considered to be the largest scale economically justified, because, in planetable methods, any increase in mapping scale inevitably causes a proportional increase in map-preparation cost. At one time, the only areas considered as justifying any larger publication scale were so-called special areas, such as metropolitan areas, mining districts, highway strips, and similar narrowly restricted projects. The 1:24,000 scale, however, has been increasingly regarded by important map users as essential for the entire areas of the more developed states, and for the entire areas of widespread projects such as the Tennessee Valley Authority, and Bureau of Reclamation activities in certain Western States. Now that photogrammetry is the basic process, the use of a larger publication scale does not involve nearly as great an increase in over-all mapping cost as was the case with ground surveys. It is obvious, of course, that the cost of *map-finishing* operations will be increased approximately in the ratio of 4 to 1, because the 1:24,000 scale requires four sheets to cover the area of a single sheet on 1:62,500 scale. The map-finishing cost, however, represents a relatively small part of the over-all mapping cost.

In photogrammetry methods, actually it is the contour interval that has the greatest effect on the map-compilation cost as well as the over-all cost. This is because the camera is flown at a higher or lower altitude that is approximately in proportion to the contour interval. Lowering the camera altitude by one-half requires four times as many photographs to cover a given area. When it is realized that the costs for control surveys and photogrammetric compilation are somewhat in proportion to the number of photographs used, the effect on over-all mapping cost of contour interval, and resultant camera height, is readily understood. For these reasons the Geological Survey has a general rule that, in case of doubt as to publication scale, select a larger; in case of doubt as to contour interval, also select the larger. In the latter case, to be sure that appropriate topographic detail is shown in the flatter terrain and at critical topographic features, half-interval supplementary contours are utilized. These are usually added by planetable during the field-completion survey. They appear as dotted lines on the published map, and hence are readily distinguished from the regular contours. If half-interval or other supplementary contours are used judiciously and consistently, the map will convey to the user almost identically the same elevation information, for all practical purposes, as would a map using the smaller interval throughout.

The foregoing explanation is intended to give a general idea of how modern aerial photogrammetry is used by a national mapping organization. The remainder of this discussion is intended to show that photogrammetry can be just as useful a tool to other engineers.

DEFINITION

Many people express curiosity as to the origin and meaning of the interesting word "photogrammetry." It is based on three Greek words, one meaning light,

another meaning a drawing or graph, and the third meaning to measure. The root words, therefore, originally signified measuring graphically by means of light. The modern definition is that photogrammetry is the science of making measurements from photographs and interpreting photographs. To mappers and engineers, it usually is taken to mean the science of utilizing aerial photographs in making maps.

Photogrammetry is frequently divided into specialties or categories, according to the type of photographs used, or the manner of use. For instance, when the photographs are taken from points on the ground surface, it is called terrestrial photogrammetry. Aerial photogrammetry denotes photographs taken from an airplane, and these may be either vertical aerial photographs, or oblique aerial photographs. Stereo-photogrammetry means that overlapping pairs of photographs are to be observed and measured in a stereoscopic viewing device, which gives an exaggerated three-dimensional view, and creates the illusion that the observer is viewing a relief model of the terrain.

NON-ENGINEERING USES

Photogrammetry in its broad sense finds many applications in fields other than engineering. For instance, photogrammetry is used extensively in petroleum prospecting and other geologic investigations, in geographic explorations, in soil classification, in forestry and timber cruising, in medicine and surgery, and in police investigations. By use of stereoscopic X-ray pictures, we are told, surgeons can tell more precisely where and how deep to cut, and how to avoid vital organs. Equipment for modern crime-detection procedures frequently includes stereoscopic cameras, which are used to procure three-dimensional scenes of the crime or accident. It is said that these are so realistic when viewed in a stereoscope that they assist materially in reaching correct solutions, and also make convincing evidence for judge and jury. The latest novel use of photogrammetry is reported by a clothing manufacturer specializing in made-to-measure suits for men. Measurements of each customer are obtained by photographing the individual from different angles while he stands in front of a full-length mirror which has been marked with a grid of small squares. We are told that this yields more scientific measurements and enables the tailoring firm to guarantee a perfect fit at the first try. Alert engineers probably could pick up many suggestions on the utility of photogrammetry from such diverse fields as medicine, crime detection, and tailoring.

Vertical aerial photographs are best known and most used by map makers and other engineers. Vertical photographs are actually, of course, only near verticals. Although the intention is to procure absolute verticals, approximate verticals are the best we can get so far under actual flight conditions. Tip and tilt, in some degree, are present in all so-called vertical photographs. For many practical purposes, good near-vertical photographs are actually so nearly vertical that they may be used as such without any correction. In precise contouring instruments, the amount of tip and tilt is readily determined and rectified by adjustments provided in each instrument.

ENGINEERING USES

Engineering uses of air photographs range all the way from a quick study of a single photograph to the compilation of very precise construction-site maps

showing accurate one-foot contours. A brief list of other engineering uses in order of increasing complexity would include: (1) stereoscopic examination and interpretation of overlapping pairs of photographs; (2) compilation of photographic mosaics, ranging from simple uncontrolled assemblies to precise mosaics having accuracy approximating that of a standard map; (3) compilation of skeleton planimetric sheets and plats showing property lines, using radial-line template procedures for establishing horizontal position and scale; (4) compilation of reconnaissance maps showing form lines or approximate contours, using the small and inexpensive stereoscopic plotters; (5) determination of spot elevations and plotting of profiles for preliminary planning and design, using better-grade stereoscopic plotting instruments; and finally (6) preparation of bona fide standard-accuracy contour maps, bolstered by field-completion surveys where necessary.

INTERPRETATION OF PHOTOGRAPHS

When the photographs are to be used as such, without converting to conventional maps, it is necessary that the interpretation of the photographic images be done by persons thoroughly trained in aerial-photograph interpretation. To untrained observers, the images on the pictures are sometimes undecipherable, and frequently misleading. Completely erroneous conclusions can be reached inadvertently by those who are not well trained in the fine points of photo-interpretation.

CHARACTERISTICS OF PHOTOGRAPHS

Another hazard in having untrained people use photographs is that they may treat them as the equivalent of maps. Those who make professional use of aerial photographs must have a clear understanding of the geometric characteristics of photographs, and in what way, and when, they can and do differ from conventional maps. A photograph is a perspective view, or perspective projection. A map, on the other hand, is an orthographic view or projection. An aerial photograph will be the exact equivalent of a map only when the terrain being photographed is flat and level, and the photograph is absolutely vertical.

To illustrate, a tilted photograph obviously has no uniform scale throughout, but instead is of constantly changing scale. Also, when the terrain photographed is hilly or mountainous, displacement of images on the photograph due to relief of the terrain becomes a significant factor. That is, objects at low elevation will show on the photograph too near the center of the picture, while objects at high elevation will show too far away from the picture center. One disconcerting result of this is that long tangents of such features as roads, transmission lines or fence lines, which follow the ground surface up and down hill, will usually appear on the photograph as a wiggly line of curves and angles. Such tangents across hilly country will show on the photograph as straight lines only when the route happens to pass through or near the picture center.

Fortunately all of these characteristics, which make an aerial photograph different from a map, follow simple laws of geometry, and once understood can often be a help rather than a hindrance. It is the characteristic of relief displacement, for instance, which makes possible the measuring of elevations and the delineation of contours from aerial photographs.

TYPES OF PHOTOGRAPHS

Engineering organizations contemplating the use of photogrammetry are usually first concerned as to the type of aerial photographs they will require, and how these may be obtained. It is frequently proposed that a large area, such as a state, be covered with one set of general-purpose photographs, in the belief that a single set of photographs will serve all purposes of all users. This is not usually so. It is, of course, a worth-while project, and furthermore a new set of up-to-date pictures should be reflown perhaps every five to ten years, but it must be realized that seldom will one set of pictures actually be suitable for all purposes. For example, photographs which are to be used for compiling accurate contour maps usually must be specially flown for each mapping project, under specifications appropriate for the map scale, contour interval, and plotting instrument to be used. Also, these photographs should be obtained when the trees are defoliated, and when the sun angle is as favorable as possible, which means in early spring, just before the trees leaf out. Photographs for agricultural and forestry studies, on the other hand, usually should be mid-summer pictures, when the crops are growing and the trees are in full leaf. Aerial photographs are actually low in cost, relatively, and substantial economy is usually attained by having new pictures specially flown for each major photogrammetric project. As of today, aerial photographs of almost any type can be readily obtained from several photographic flying concerns.

ORGANIZING FOR PHOTOGRAMMETRY

Another question which concerns engineering organizations planning to utilize photogrammetry is how best to have the work done—how to organize and equip. Generally speaking, there are two basic methods available. One is to acquire a full complement of instrumental and laboratory equipment, employ a full force of professionally trained photogrammetrists, and handle all work on a force-account basis. The other is to employ a staff photogrammetrist, well-trained and blessed with good professional judgment, as advisor on policy, procedures, and techniques, and to have the actual photogrammetric work done through contracts with the well-equipped and experienced photogrammetric commercial organizations. Several of these concerns are now nationally recognized as well qualified for most types of photogrammetric work, and new firms are being formed from time to time. The contract method probably would have some advantages for state or local-government engineering organizations, particularly during the present period of rapidly changing developments in the science.

SUMMARY

In summary, photogrammetry can be an exceedingly useful and efficient tool for engineers as well as mappers. It may be used in a simple manner, with simple equipment, for reconnaissance or study purposes, or, at the other end of the scale, it may be used in connection with complex and costly instrumental equipment for determining elevations and making ultra-precise contour maps. Regardless of the type of use, the user should be well-trained, else results may be disappointing, if not actually misleading. Photogrammetry certainly is not a cure-all for engineers' troubles, but it can be a great help as a means of supplying reliable basic data at low cost.

Surveying in Mammoth Cave

By C. R. MASON

TOPOGRAPHIC ENGINEER, U. S. GEOLOGICAL SURVEY

OUR PRESENT CIVILIZATION has advanced considerably from that of our pre-historic cave-dwelling ancestors. Today, with the advent of the atom bomb and modern implements of war, man has again turned to the cave for his preservation. Concerted effort is being made to explore the possibilities for placing war plants underground, for storing ammunition and priceless treasures in caves, and for using caves as havens for human refuge in the event of attack.

With this in mind, it is interesting to recall a surveying project of Mammoth Cave, Kentucky, in 1935–36.

While the purpose of this survey was not for the reasons mentioned above, one may speculate, nonetheless, on the possibility of using the information secured at that time in connection with some of the problems which the atomic age has now raised. The data obtained from this survey provide almost complete information on the principal avenues of one of our largest and best known caves. The story of the survey and the methods used will no doubt prove interesting to many who are interested in speleology.

In December of 1935, the U. S. Geological Survey, in cooperation with the National Park Service, assigned a survey party to Mammoth Cave to establish nets of transit traverse and levels through the cave to determine the location of main passages, outstanding formations, and features of the cave with respect to the known property lines outside, and other pertinent data needed by the National Park Service.

H. D. Walker, topographic engineer in charge of the project, was assisted by F. F. Blankenbaker and the writer. Additional help was secured through the cooperation of the cave authorities. Several members of the party were obtained from a nearby CCC camp to act as rodmen and to carry the gasoline lantern used for illumination.

Discovered in 1799, Mammoth Cave has long been a favorite tourist attraction. It lies in Edmonson and Barren Counties, Kentucky, 100 miles south of Louisville and approximately the same distance north of Nashville, Tennessee. The cave begins about 7 miles west of Cave City and extends westward for more than 4 miles. To date more than 150 miles of underground avenues have been explored. The cave has five man-made entrances and one original natural entrance. Chief among the man-made entrances is the one known as Frozen Niagara Entrance, noted for its beautiful formations. The original natural entrance, generally called Old Entrance, is noted for its historic features, immensity, pits, domes, and Echo River.

One of the cavern's principal claims to historical fame was developed during the War of 1812 when saltpeter was furnished from the cave for the manufacture of gunpowder. During this time, our Government, being excluded from foreign sources of supply, had to depend largely on our American caves for this necessary commodity. Despite the crude methods used for its manufacture, the saltpeter vats and water pipes are still to be seen in a remarkable state of preservation. The pipes were small trees or saplings hollowed through the center and tapered at one end to fit snugly into the opening of the end of a similar "pipe." These

were held securely by crude iron bands. To an engineer, a study of the processes used in the mining of this precious material is most remarkable. The Treaty of Ghent, ending the war, also ended the heavy demand for saltpeter, and since that time Mammoth Cave has been known chiefly for its exhibition value. This project together with the comments of scientists, philosophers, and visitors from all over the world have been major factors in making Mammoth Cave an internationally known attraction.

The guides who conduct visitors through the cave tell its story with facts and legends. Many traditional stories about the cave have accumulated in the 150 years since its discovery. One might go on writing about the wonders of Mammoth Cave without limit, but this report will cover chiefly the work done by the survey party.

As the members of the party were inexperienced in cave surveying, the many problems encountered had to be solved as the survey progressed. Many times the ingenuity of the crew was taxed, but each problem was solved successfully before the completion of the work.

A reconnaissance was first made of the cave by the chief of party and Paul Miller, Park Service resident engineer, to determine the area to be surveyed and to select sites for the location of permanent traverse stations and azimuth markers. Elevations were later determined for these markers. These elevations can be used for extending future surveys in the cave.

The job of assembling the necessary equipment for the work followed the reconnaissance survey. It had been previously decided to use a 30-second K&E transit. Because of the narrow passages, low ceilings and the almost inaccessible ledges available for instruments setups, a tripod with telescopic legs was used. Some portions of the cave were electrically lighted, but this light was not bright enough to permit reading a transit vernier or a level rod, nor was it sufficient for reading the tape when measuring between traverse stations. Coleman gasoline lanterns were found to be satisfactory for illumination. Since this type lantern is used by the guides in escorting tourists through the cave, an abundance of lanterns was available.

At this point the party encountered one of their first problems—one that does not occur in the usual routine of running a transit traverse line. The reconnaissance work revealed that the distances between traverse stations would vary greatly, ranging from 6 feet to the longest shot of 402 feet. A major portion of these distances lay within the 15- to 40-foot range. At such short distances, the use of the ordinary range pole for transit traverse work was impractical, since it would be next to impossible for the transit man to determine when the vertical hair was exactly centered on the range pole.

In solving this problem, the chief of the party came up with the perfect solution, as he did in most of the other problems that arose. A three-cell flashlight was mounted on top of a Bumstead tripod, and on the top of the flashlight was mounted a small wire hook in such a manner that a plumb bob could be suspended on a black string. This arrangement allowed the string to hang across the front of the flashlight lens, about $\frac{1}{2}$ inch away to permit free swing. The black string offered an excellent target upon which to center the vertical hair. A small piece of vellum was used to cover the lens of the flashlight to soften and cut down the glare of the light. The plumb bob could then be centered directly over the traverse station by moving the tripod legs around. The flashlight was also mounted

in such a manner as to allow it to be moved from side to side in the horizontal plane. After each set of deflection angles was turned, the flashlight was snapped off and the entire assembly was moved to the next station and centered in the usual manner.

Because of the numerous stations to be established and the great number of angles to be read without having an azimuth check, it was deemed wise to turn six deflection angles, three direct and three indirect. Thus a better mean angle was obtained between stations. A Polaris observation was made each time the line emerged from the cave.

The usual USGS procedure of putting in transit traverse stations was to keep the distances between stations at an even multiple of 10 feet for ease in computing. (With the computing machines now in use, this is not necessarily the case.) This procedure could not be followed in the cave survey. Due to the structure of the cave, its many right-angle turns and the short distances from wall to wall, it was mandatory that the stations be placed at the point which would allow the longest possible sight ahead.

The transit traverse station markers (other than the permanent markers) were 2-inch square oak hubs, about 4 inches long and tapered at one end with the standard surveyors tack in the top. These hubs were driven flush into the clay floor of the cave and proved to be quite substantial. They were later used as points of elevation when a level line was run through the cave.

The traverse line started from a U. S. Coast and Geodetic Survey triangulation station and a second-order transit traverse was run on the surface, passing all the entrances to the cave. The line entered the Old Entrance and followed the predetermined routes selected by the chief of party and the Park Service engineer.

The permanent traverse station and azimuth markers were standard USGS bronze tablets set either in the rock floor of the cave or in 3-inch iron pipes filled with concrete. In turn, the pipes were set in position where the earth in the cave was of sufficient depth to allow them to be buried, with about 2 inches protruding above ground. These markers were to be set at the junction of two or more avenues, or routes, in the cave in such positions that they would not be seen by the tourists visiting the cave, yet they had to be located to allow occupation by the survey party. Years of field experience indicated that these bronze markers set in concrete posts in the ground are most attractive to souvenir collectors.

The distances between traverse stations were measured with the usual standard procedure set up by the USGS. Caution was exercised to check the tape reading twice to eliminate the possibility of error as much as possible. All distances were checked by a reading on a stadia rod graduated to read to 1/100 foot. This was a check against any gross error in the chaining.

In most instances the cave passages were wide and high enough to permit the transitman to set up the instrument in the normal manner, but quite often setting up the transit in narrow passages was quite a problem. Because of the short distances between the cave walls it was necessary many times to use two men in turning an angle; one man took the backsight and the other took the foresight. There was not enough room to permit walking around the transit.

One particular place, known as Fat Man's Misery, was too narrow to set up the transit and the tripod. This problem was solved by the use of a 2- by 6-inch board with a hole bored in the center to allow the plumb bob string to swing

freely. The board was set up with each end resting on a rock ledge along the cave wall. The transit was set on this board over the station and the angles were turned, with two men to do the sighting. After passing through this difficult passage, the group entered the area appropriately called The Hall of Great Relief.

Another particularly difficult situation arose in running a line through one of the untraveled passages to reach a point in the cave which lay under a piece of land of questionable ownership. There was only about 18 inches clearance between the floor and the cave roof. The men had to crawl on hands and knees to negotiate this one; as a matter of fact, it was more nearly a matter of crawling on their stomachs. Because of a bend in the passage, it was necessary to make a setup midway through. For this particular setup, the aluminum base upon which the transit is fastened in the carrying case was used. The transit in place on this base was centered over the station. Again the two-man sighting system was used. In such close quarters, there was an added discomfiture—that of the heat generated by the gasoline lanterns. Fortunately, there were not many such instances as this to plague the party, though many passages were almost as bad.

All lines were tied to one or another net inside the cave. The final ties were made to the second-order traverse line outside and checked with a Polaris observation. Upon completion of the transit traverse work in the cave, a total of more than 21 miles of traverse had been run, and ninety-three permanent markers had been placed inside the cave. The computations showed that all lines had closed well within the allowable limit of error.

After the traverse job, a level project was started. The line of levels was to follow the same route of the transit traverse line with a few exceptions. This line, as with the traverse line, was also started from a previously run line outside the cave. Other problems of making preparations not in line with the usual procedure of running levels were encountered.

In addition to the regulation level rods which could be used where the cave ceiling was 14 or 15 feet high, two rods were sawed off for use in parts of the cave where the ceiling was low. A K&E Dumpy level was used together with Philadelphia rods for the high ceiling and sawed-off New York rods were used for the low ceiling. The gasoline lanterns continued to be used for lighting, but reflectors were placed on them to concentrate the light on the target. For a high rod (where the target was too high to be reached by a man standing), a stick was designed with a hook on the end. The lantern was hung on this hook and hoisted up to throw light on the target. As stated previously, each traverse station was marked with a wooden hub driven into the clay floor of the cave, and elevations were established on each of these stations as well as on the permanent markers. In addition to this, the distance was measured from the station to the cave wall on each side, and to the roof of the cave above.

Measuring the height of the cave roof also proved to be quite a problem, as in many instances it was too high above the floor of the cave to be measured by a tape or a stadia rod. In some parts of the cave, especially in one section known as Cathedral Domes, there were huge domes extending up as much as 176 feet. To measure these domes, small rubber balloons were filled with helium, and a long string was attached. Three balloons were sometimes needed to obtain buoyancy capable of pulling the string up, and the balloons were allowed to float upward. Since there were no pronounced air currents moving, the balloons ascended directly to the ceiling. Sharp protuberances of rock on the ceiling often punctured

the balloons and made it necessary to replace them. The string was then held on the ground and marked; the balloons were hauled down and the string measured, thereby giving a measure of the height of the dome above the station. The height readings were recorded in a notebook with the number of the transit traverse station. When the geodetic position of the station was computed, the elevation above sea level, the distance to each wall of the cave, and the height of the roof above were entered in the record, thereby giving complete data concerning that point in the cave.

Along the regularly traveled routes of the cave are many pits and holes, some as deep as 105 feet. These pits, incidentally, were located as to geodetic position when the traverse lines were run through the cave. When the level line was established, an elevation on the bottom of each pit was obtained. This was accomplished by tieing a weight on the end of the tape and lowering it to the base of the pit. The depth was measured to the nearest tenth of a foot. This information was recorded for future reference and entered into the permanent notes. As is the case in most caves used for commercial purposes, each unique onyx formation, pit, dome or outstanding attraction is given a name. It was interesting to note the description of certain features as placed in the survey notebook. For example, the record for Bottomless Pit read, "elevation at bottom of Bottomless Pit is . . ."

As mentioned before, all lines were tied to an outside bench mark. In one instance, in order to carry the line outside, it was necessary to run levels up a flight of stairs containing 185 steps. When the rod was set up on the step to be read for the foresight, it was learned that the distance between the rod and the level instrument (about 4 feet) was too short to allow sharp focusing. For a while this appeared to be an insurmountable problem, with the only solution being to double run the line to another of the five entrances in order to get outside for a tie. Here again, Mr. Walker came up with the answer.

His idea was to slope chain the distance from the bottom to the top step, and with the transit at the base elevation to turn a vertical angle to the point on the step at the top. A reciprocal angle was read for a check, from top to bottom. By computation, the vertical leg of the triangle represented the difference in elevation between the bottom and the top step. The level line was picked up at the point on the top step and carried to the tie point.

The temperature of the cave remains more or less constant, about 54° F. The outside temperature in May was as much as 85°, so it was necessary when running from the cold temperature inside to the warm temperature outside to wait for several minutes to allow the bubble on the level to adjust itself to the expansion change.

Mammoth Cave is made up of five different levels, which we might visualize as five floors. All are connected, of course, but it is interesting to note how deceptive distances and relative differences in elevation can be under these circumstances. The guides and all those concerned with the operation of Mammoth Cave had always thought that one particular floor level lay over another. This can easily be understood as each was entered from a different entrance, but when elevations were established through these two places, exactly the reverse was true. The level thought to be the upper one proved to be, in fact, the lower one.

To sum up: Chief among the uses of this survey was the determination of the position of the cave in relation to the known outside property lines. The junction

of each avenue became known, as did the location of all pits, domes, and the featured show spots, such as the Snowball Dining Room, the spacious room in which hot meals are served to tourists. Echo River, the underground river that flows through the cave, and many other well-known features in the cave, can all be precisely plotted, and their relation to outside features can be determined easily. In extending the present electrical lighting system, it will be easy to locate positions where new inlets are desired, and additional power and telephone lines can be brought in from the outside. After reaching the desired location on the outside of the cave, the crew will know exactly how much ground they will have to dig or drill in order to get the line into the cave. If new entrances are needed, the crew can readily know the most feasible spot for constructing them.

To describe the many humorous and trying situations encountered on this job would require more space than is allowed here, but overall it was a most interesting project. Those of us who took part in the job look back upon it with a feeling of satisfaction and with a heightened appreciation of the adage that says, "Necessity is the mother of invention." Never is that saying more true than in respect to cave surveys.

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Africa Posed Problem for Map Makers

THE NATIONAL GEOGRAPHIC'S new map of Africa, included in a recent issue of the magazine, throws light on the "Dark Continent" to the scale of 189.4 miles to the inch.

It marks the map-making staff's latest triumph of putting the round earth on flat paper.

The part of the earth's spherical surface the African mappers had to put on flat paper curves from Dakar, on the west coast, to the Arabian Sea, some 4500 miles eastward. From north to south, the distance is better than 4800 miles.

To start the mapping job, they pick a projection—not just any old projection, but that one of a dozen or more available ones best suited for the area to be mapped. For Africa, their 116th major map supplement, they selected the Chamberlin Trimetric Projection.

It's the society's own pet projection, having been devised by Wellman Chamberlin, staff cartographer. It's "fairly complicated and involves spherical computation," they say, but it does give "a minimum scale variation" for the particular area mapped.

The area "projected" is only the start of map making. Cities, towns, railways, roads, airfields, terrain, boundaries, all must be precisely located within the grid lines.

To accomplish this, four separate maps are made. One shows the parallels, the meridians, place names, railroads, and other marks of man excepting roads. The others show roads, the drainage and shoreline, and relief.

Lithographers make plates of the four, and the rest is done in color as the presses roll. Four press runs are required for the principal colors, and three extra ones for political tints, marking off areas of political domain and the ocean blue. With definite shading combinations, the finished product is known as a 10-color map.

Precision is the keyword. One plate slightly "off register" might inundate land with ocean blue. Man-made works, in black, might appear miles off their true location. Red roads might pass over unbridged lakes. All of which means that everything must be checked and double-checked to produce these maps which go to some 1,600,000 customers.—*The Washington Post*, April 21, 1950.

Surveying Instruments Enter the Shop

By PHILIP KISSAM

PROFESSOR OF CIVIL ENGINEERING, PRINCETON UNIVERSITY

MANY PROBLEMS in industrial surveying are much the same as in surveys for construction. Maps and profiles are required as a basis for industrial facilities and surveying techniques are used for controlling construction and installation. But the American surveyor is now faced with a brand new problem in industrial surveying for which he is ill equipped. This problem has been created by the important movement in this country toward the building of very large products with interchangeable parts. It is clear that this development is not a flash in the pan, but a permanent trend. Heretofore, interchangeability has been confined to parts of small dimensions. Standard shop practices have been developed to produce the desired accuracies. Control gages, precision bench plates, indicators, and the like have successfully produced the near-perfect jigs that have controlled the products.

But during the past war the airplane industry was suddenly confronted with the necessity of making airplanes with interchangeable parts. This required great jigs built to very small tolerances. Standard shop practices could not handle the job and surveying practices began to make their way into the shop. Gravity as a reference direction supplanted the bench plate; optical sights took the place of wires, straightedges, and indicator gages. Surveyors found themselves faced with new problems. Thousandths of an inch replaced the hundredth of a foot as a unit of measure. Sights a few inches long were required instead of hundreds of feet.

ASSETS OF SURVEYING INSTRUMENTS FOR SHOP USE

There are three important assets inherent in surveying instruments not found in shop measuring equipment. The first is the use of gravity for a reference direction. The spirit level gives the direction of gravity to such a degree of accuracy that a thousandth of an inch can be recognized at 20 feet. In shop practice a reference direction is established by a flat metal surface—a bench plate. It is machined to a high degree of flatness. But a bench plate cannot be kept accurate if it is much larger than 24 inches in any direction. Temperature changes and variations in support alone introduce curvatures that destroy any accuracy of manufacture. With a surveying instrument, nearly perfect horizontal planes, absolutely parallel with each other, may be established wherever desired.

The second asset is the superb qualities of the optical sight. With a good target, the probable error of observing the position of a point is 0.3 second of arc. The observer is definitely conscious of 1.0 second, which is 0.001 inch at 20 feet. When a spirit level is combined with an optical sight, the combination will produce a horizontal plane at any level desired with a probable error of not more than 0.5 second of arc. This accuracy corresponds to that of a bench plate 40 feet in diameter, held to a tolerance of 0.001 inch.

The third important asset is the quality of the azimuth and elevation bearings combined with the reversibility of the transit instrument. These bearings pro-

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vide nearly pure rotation for the line of sight. By reversing the instrument it is possible to adjust the relative position of these bearings and the line of sight so that nearly perfect vertical or horizontal planes can be generated wherever desired. There is no shop equivalent able to establish two planes at 90 degrees to each other with comparable accuracy.

LIMITATIONS OF SURVEYING INSTRUMENTS

While surveying instruments are capable of establishing the relative orientations of planes to a very high degree of accuracy, these results are not attained without great care on the part of the observer. Usual field procedures must be considerably modified and new methods introduced.

For giving line and grade in the field the most important geometric requirement of the transit is that the line of sight be perpendicular to the elevation axis. This condition is usually carefully maintained by most transitmen so that a line can be prolonged by reversing the instrument without double centering. Other relationships are comparatively unimportant in the field. The telescope bubble may be slightly out of adjustment, as it costs little more to balance the length of sights than to use unbalanced sights. The perpendicularity of the elevation axis to the azimuth axis has little effect, as only seldom is the line of sight inclined at a high angle, so that reversal is not costly.

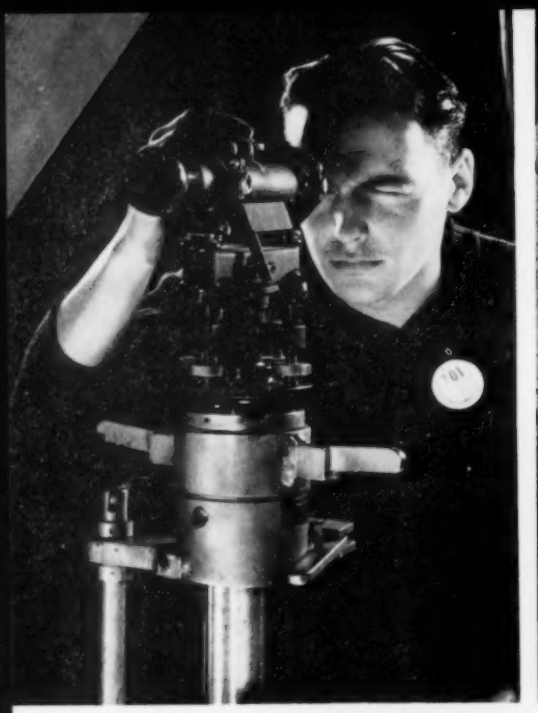
In the shop, so many observations are made at high angles that it is impractical to reverse the instrument. This circumstance magnifies the importance of the perpendicularity between the axes. Accordingly, this relationship must be carefully adjusted. Level shots cannot be conveniently balanced. Thus the telescope bubble must be in perfect adjustment. Very short sights must be taken so that the focusing slide must be perfectly aligned. In fact, since the instrument can seldom be reversed without serious loss of time, every transit adjustment must be nearly perfect except perhaps that of the vertical circle.

Since sights at high vertical angles are used constantly, great care must be exercised in leveling. It is nearly essential that the telescope level be used for leveling at every set-up. Also it is impossible to place the instrument on a desired line to the required accuracy by merely setting up over a point with a plumb bob. In every case the instrument must be "wiggled in" so that the line of sight itself is aligned with the desired points. This process, of course, is decidedly tedious. It requires re-leveling at each trial and the trials must be continued until the line of sight is within a few thousandths of an inch of the desired position. Several methods have been tried or suggested to overcome this difficulty.

One of the first efforts to simplify "wiggling-in" was to mount the instrument on a small carriage which slides laterally on a short pair of ways like a lathe tool. With this device it is possible to shift the instrument without deranging the level very much, but unfortunately it is always necessary to re-level, thus disturbing the line of sight and requiring another shift.

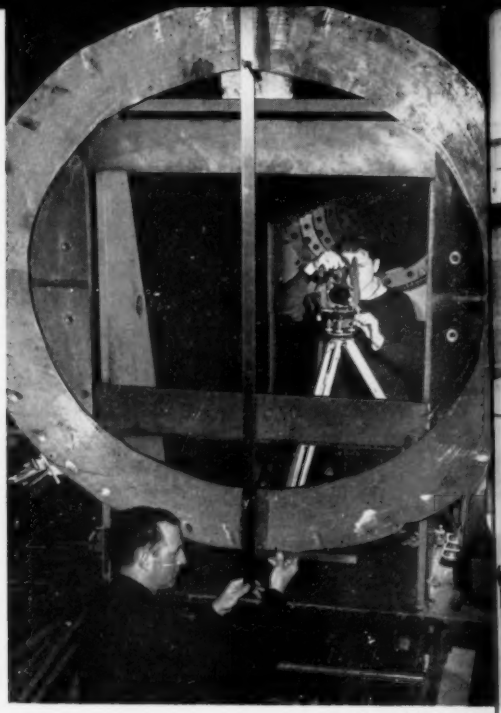
Frequently it is necessary to set the line of sight at a predetermined height. This procedure is next to impossible with an ordinary tripod. The instrument must be mounted to a vertical post with an adjustable inside support that imparts nearly linear motion. This device usually disturbs the alignment slightly and always disturbs the level.

Another scheme is to aim a collimator at the cross hairs after the instrument



McGraw-Hill Book Co.

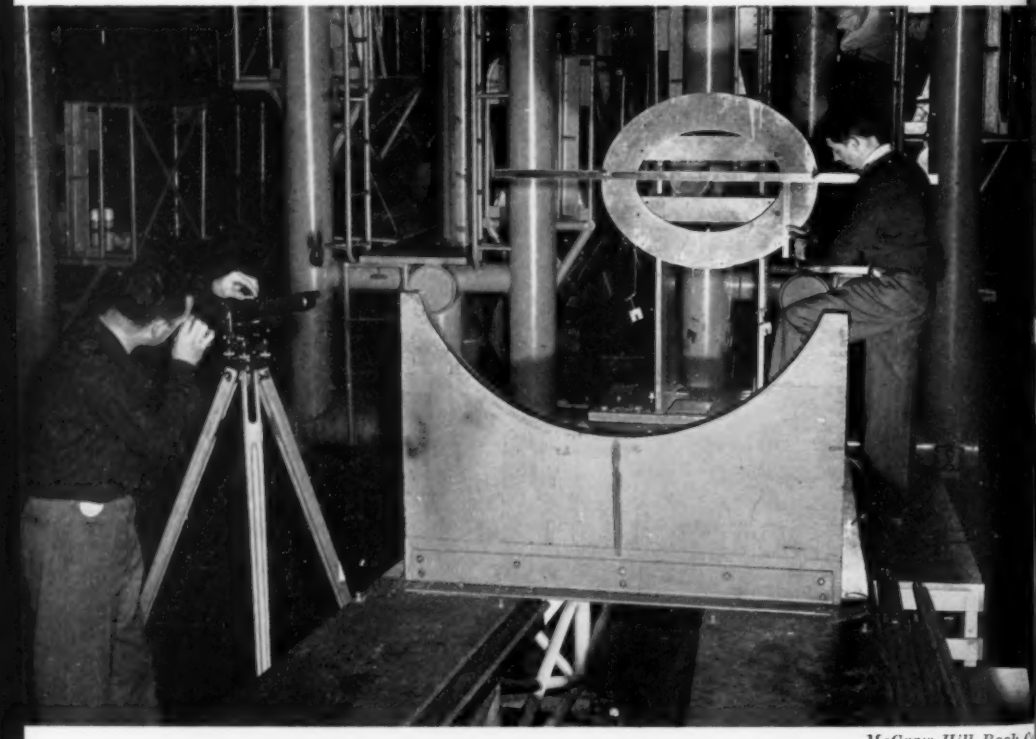
Wye level mounted on elevating post for shop use. Boeing Aircraft Co.



McGraw-Hill Book C

Establishing vertical plane at horizontal longitudinal center line of a jig.

Surveyin



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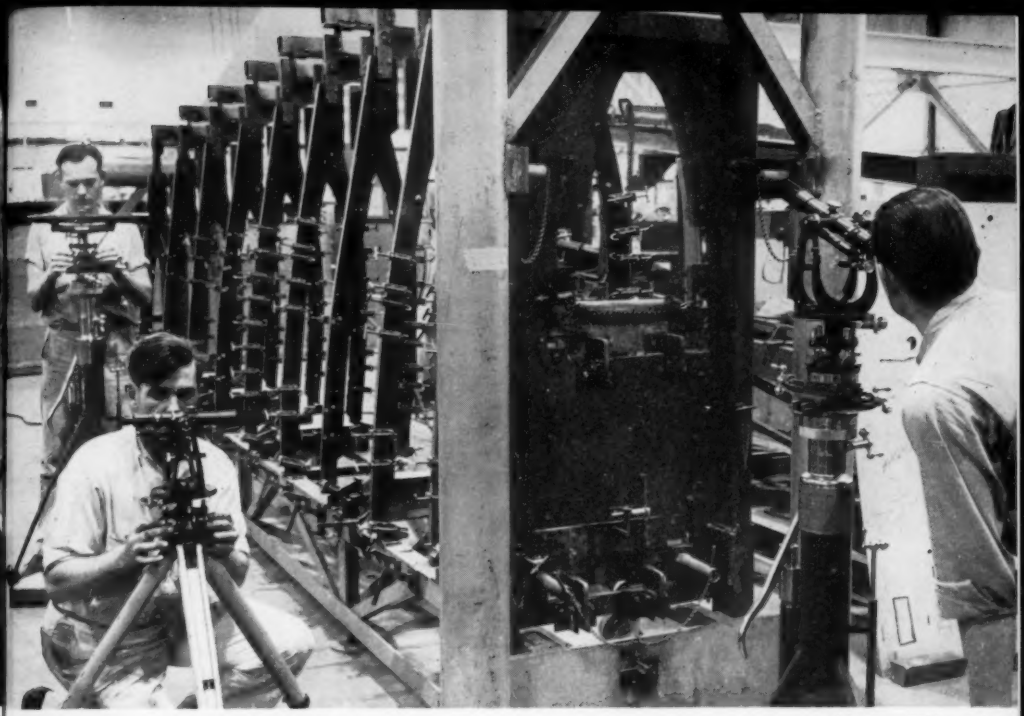
stablishing horizontal plane at horizontal longitudinal center line of a jig. Eugene Dietzgen Co.

Fairchild Engine & Aircraft Co. an

Deflections



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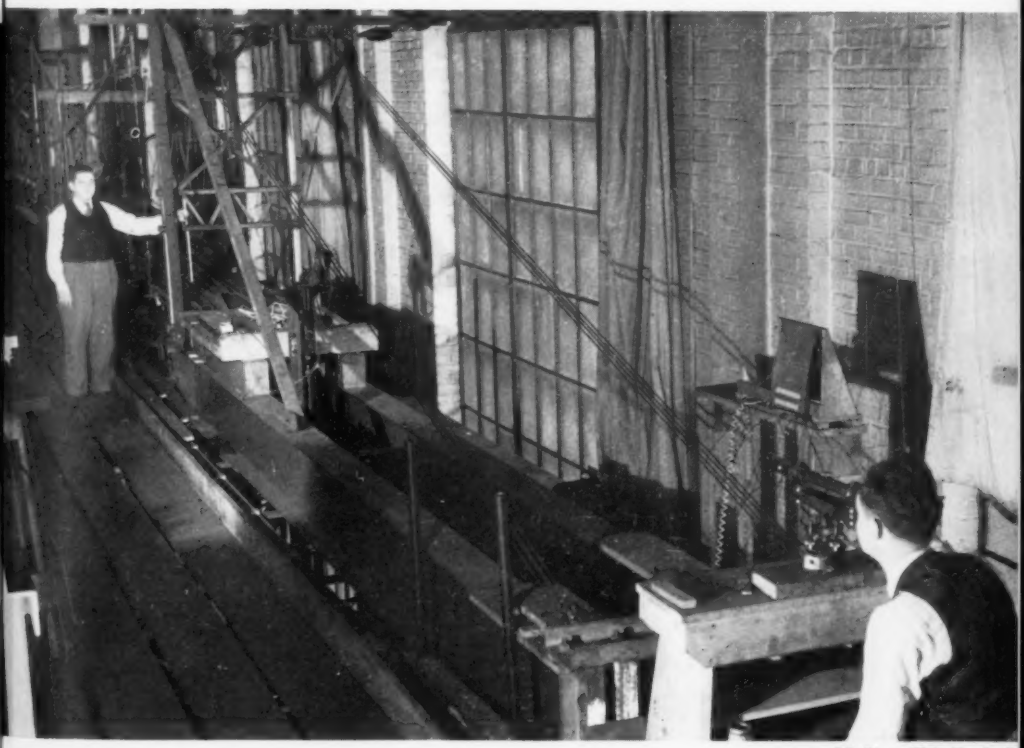
Surveying equipment aligns jig for airplane wing section. C. L. Berger & Sons and Douglas Aircraft Co.



McGraw-Hill Book Co

Deflections in model suspension bridge are measured by surveying instruments. John A. Roebling's Sons Co

has been brought nearly into position and the line of sight leveled and aimed parallel to the points required. Alignment can then be tested very quickly thereafter by sighting the collimator. However, if it is necessary to establish a plane, the instrument must be re-leveled and the method reverts to cut and try.

USE OF PLANE PARALLEL SUGGESTED

The writer suggests that a plane parallel be mounted in front of the objective, as is done on some of the German levels. When the plane parallel is rotated, the line of sight is moved parallel to itself, the translation being in the plane of rotation. If the device is mounted so that its axis of rotation can itself be rotated around an axis parallel to the line of sight, the line of sight can be translated in any desired direction. Except in the unusual case when vertical or horizontal angles must be measured from a given point, the parallax introduced would not affect the results.

With an engineers' transit, that is, one equipped with a telescope level, properly used, it is possible to establish a horizontal plane and also a vertical plane in any desired azimuth. Development in the future should provide a means of easily placing these planes where desired.

When a jig is to be lined up, it is almost essential that the jig be supported so that the planes to which the dimensions are referenced are placed vertical and horizontal. Any other procedure requires voluminous computation. Usually the jig can be placed in nearly the proper orientation before precise measurements are established on it. The reference frame can then be precisely established in accordance with the direction of gravity.

If precise points already exist on the jig, the first step is to jack the jig into position so that the horizontal reference plane is exactly horizontal. This, of course, is a difficult cut-and-try procedure. Thereafter the transit is placed on the desired vertical planes, as required, by "wiggling in."

Measurements are made from the line of sight to the various parts to be located with steel scales of measuring bars with caliper ends. When in position they are permanently attached to the jig by various means. Probably the most popular method is to seal them in position by an alloy called cerromatrix, which melts at low temperatures.

PROBLEM OF VERY LARGE JIGS SOLVED

During the war it was found nearly impossible to build two large jigs, to the same plans, that were exactly alike. To overcome this difficulty, a master dummy part was first constructed according to the original drawings, using surveying techniques for measurement. The necessary jigs were then made to fit it. When two factories were making the same airplane it was necessary to ship the master dummy from one factory to another. The shipping problem became very acute as the size of the airplanes increased.

A remedy for this difficulty has been devised by British engineers. Their scheme is to make the jigs in many small parts, each carrying extremely accurate reference points well arranged for accurate observation by optical lines of sight and direct measurement. The parts are small enough to be made precisely in accordance with the drawings.

Each jig section usually carries four reference points, about $1\frac{1}{2}$ inches in diameter, which are targets. They are actually glass reticules provided with cross

lines. The reticules are mounted in metal rings, each of which is accurately machined to a standard thickness and diameter. The glass is carefully mounted so that the cross hairs are exactly centered. The target assembly is held to the jig section by a special container from which it can be removed and replaced in the same position. The container has screws for adjusting its position. The targets are adjusted to the jig by measurements to the rings so that the cross hairs are placed on two parallel level reference lines which run at the same height throughout the entire jig. The targets are carefully spaced along these lines according to the drawings. The entire operation of placing the targets on the jigs can be completed by ordinary shop methods.

The jig is assembled wherever desired by aligning all the targets and spacing them by measurements with measuring rods equipped with micrometer ends. The reference lines are established for the assembly by mounting two collimators, each provided with a level, on a frame at one end of the jig, and viewing each of them with a telescopic sight mounted on a frame at the other end. All four optical devices are mounted in wyes for easy collimation. Targets placed in front of each collimator objective are set at the proper separation by the measuring rods. The collimators are leveled. One telescopic sight is aimed at the cross hairs of the collimator by focusing at infinity. The sight is then focused on the target and shifted parallel to itself until it points on the cross lines. By alternately focusing on the cross hairs of the collimator and then on the target, the telescopic sight is finally made parallel to the collimator and yet on line with the target.

The second telescopic sight is worked into position in much the same way except that it must be placed in line with two targets, one at the objective of its collimator and the other near its own objective. Both targets are spaced laterally by measurements from targets placed on the first reference line. Thus the two lines are level, as they are parallel with the leveled collimators. They are also parallel in a horizontal plane as they are equidistant at both ends. The various jig parts are then set by placing their targets on these reference lines and spacing them along the lines by measurement.

It is clear that surveying in the shop is still a very new process calling for many improvements. Very few production engineers are sufficiently familiar with the possibilities inherent in surveying equipment to utilize them to the best advantage. Very few surveyors are familiar enough with the requirements of the shop to realize what precision techniques are required. And finally, very few individuals are sufficiently versed in both surveying methods and shop problems to contribute to the necessary instrumentation.

Surveyors should give some thought to this new field of endeavor, study the problems of the production engineer, develop the proper techniques, demand the proper instrumentation, and finally advise the production engineer on the solutions of the new and difficult measurement problems that now confront him.

❦ ❦ ❦

SHAMELESS

Poetess Margaret Fishback, who vacations in Maine, reports that a rock ledge on the Maine coast designated as the "Old Woman" is further described in a sober U. S. Government navigation chart as "bare at half-tide."

Analysis of Probable Errors in Plane-Table Surveying

By LUIS GUILLERMO DURÁN S.

IN PLANE-TABLE SURVEYING by traversing, the combination of the graphic and the stadia errors makes an analysis of the probable horizontal closure error quite different from the same type of problem where the transit or any other goniometric instrument is involved. Furthermore, the altimetric errors of plane-table work cannot be analyzed by the methods used for precise leveling. In spite of the rather extensive literature existent on the plane-table method, available either in books on surveying in general or in those on geological surveying, the question of the precision attainable has not been analyzed from a real engineering point of view, so far as the writer knows, and some of the rules of thumb given by some authors are fundamentally wrong, as will be evident from the following discussion.

In this article an attempt is made to give a mathematical basis for engineering specifications for plane-table traversing through application of the theory of errors, but empirical results also are taken into consideration in reaching the final conclusions presented. Results of a study of the errors affecting the accuracy of plane-table work are summarized, but for the sake of brevity the derivation of formulas is omitted.

HORIZONTAL ERROR

In general, the probable error in the measurement of a distance D by stadia is, according to Pasini[1]:

$$e_d = \pm 0.000776 \frac{K}{I\sqrt{w}} D \qquad (I)$$

where K = stadia constant, I = power of the telescope, and w = number of wires in the reticle. Thus, for the alidades commonly used in geological surveying, $e_d = 0.34$ percent, approximately.

According to the general theory of errors,[2] taking into consideration all the possible sources of error in a plane-table traverse, the closure error E would be expressed by the equation:

$$E = \sqrt{(e_d^2 + e_g^2 + e_c^2 + e_b^2 + i^2)n} \qquad (II)$$

where n = total number of sights, e_d = distance error (for the average sight distance), e_g = graphic error (error of plotting, assumed to be 1/5 mm.), e_c = error due to difference in location of the instrument in relation to the point on the ground (averaged as 20 cms.), e_b = compass, or orientation error, and i = instrument constant (25 to 30 cms.).

The error e_b is assumed, according to the French School,[3] as $\frac{2.06}{1{,}000}$, or 0.10 mm. at the end of a distance of 5 cm. on the sheet, for the compass method of orientation, generally used in geological surveying.

[1] PASINI, C.: Topografía, *G. Gili*, 1925, Barcelona.

[2] BOREL et DELTHEIL: Probabilités, Erreurs, *Armand Colin*, 1934, Paris.

[3] ÉCOLE SPÉCIALE des TRAVAUX PUBLIQUES: Topographie Générale, Paris.

Equation (II) gives for E theoretical values which are only about half as large as the actual errors occurring under ordinary conditions. This discrepancy between the theoretical and the empirical values probably results mainly from the very wide range of variation of the error e_d, for it does not vary in direct proportion to D, beyond a certain limit, as is implied in Pasini's equation (I). On the other hand, it must be kept in mind that, between the distance error e_d and the error Δs in the stadia reading, the following relation exists[4]:

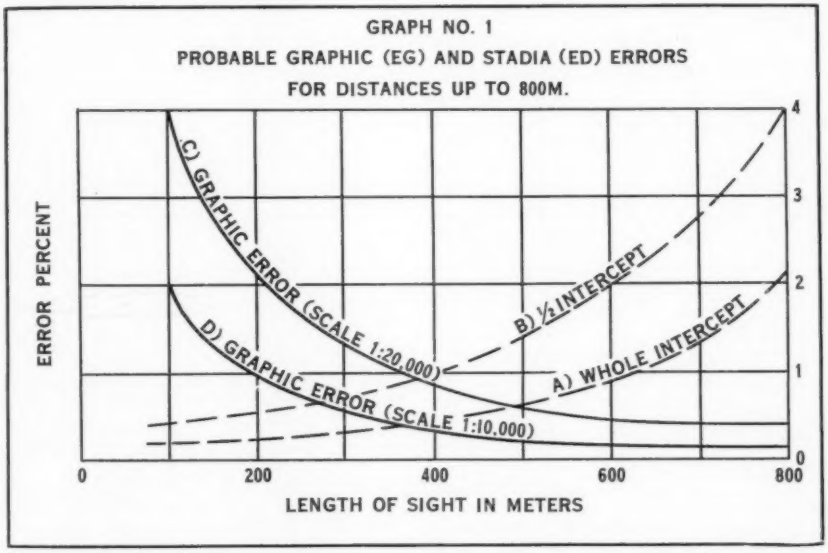
$$e_d \propto K\Delta s \qquad \text{(III)}$$

and, that this relation becomes as follows, when 1/2 or 1/4 of the stadia interval is used in the measurements, respectively,

$$e_d \propto 2K\Delta s \qquad \text{(IV)}$$

$$e_d \propto 4K\Delta s \qquad \text{(V)}$$

Another factor that has a significant influence in the error e_d is the differential atmospheric refraction. For detailed discussion of this error the reader is referred to the books of Johnson[5] and Jordan[6] and to the writer's paper published by "Petróleo Interamericano."[7]



Graph No. 1 represents an interpretation of the probable graphic and stadia errors, based on the above analytical and empirical discussion. In this graph,

[4] WERKMEISTER, P.: Topografía, *Labor,* Barcelona.

[5] JOHNSON, C. J.: Theory and Practice of Surveying, *John Wiley & Sons,* 1918, New York.

[6] JORDAN, REINHERTZY EGGERT: Tratado General de Topografía, *G. Gili,* 1944, Barcelona.

[7] DURÁN, L. G.: The Influence of Differential Refraction in Stadia Readings, *Petróleo Interamericano,* May–June 1944, Tulsa.

the errors for the whole stadia intercept and for 1/2 of it are represented by curves *A* and *B*. Curves *C* and *D* represent the graphic error (on the sheet) for scales of 1:20,000 and 1:10,000, respectively.

The following conclusions are apparent from observation of Graph No. 1:

1. For short distances the graphic error is much larger than the stadia error, and hence the distances should be carefully plotted on the sheet; it is unnecessary to attempt to secure a stadia measurement of a distance with an error less than 1 or 2 meters.
2. For long distances the stadia error is much larger than the graphic error and, therefore, it is necessary to read the stadia intercept with the utmost care; the use of pricker and lens in plotting is quite unnecessary.

Obviously, the discrimination between "short" and "long" distances will be based on the scale of the map insofar as the applications of these two conclusions are concerned.

On the basis of the above analysis of the error in distance, the total closure error for traverses of average short sights may be expressed by the following equation, according to the law of errors:

$$E = e_g \sqrt{n} \tag{VI}$$

$$E \text{ (percent)} = \frac{(e_g \sqrt{n})100}{D} \tag{VII}$$

where D represents the total length of the traverse.

Graph No. 2 was prepared with these equations for traverses with an assumed average sight of 50 m., for scales of 1:10,000 and 1:20,000.

Two practical conclusions may be drawn from this graph:

1. The relative (percent) closure error for this type of traverse decreases as the total length of the traverse increases.
2. The total closure error increases rapidly at the beginning of the traverse, and continues increasing very slowly afterwards (asymptotically).

Similar graphs could be prepared for different average sights and for other scales, using equations (VI) and (VII).

In the cases where the stadia error is much larger than the graphic error (long sights), the total and relative closure errors would be given by the following relations, instead of formulas (VI) and (VII):

$$E = e_d \sqrt{n} \tag{VIII}$$

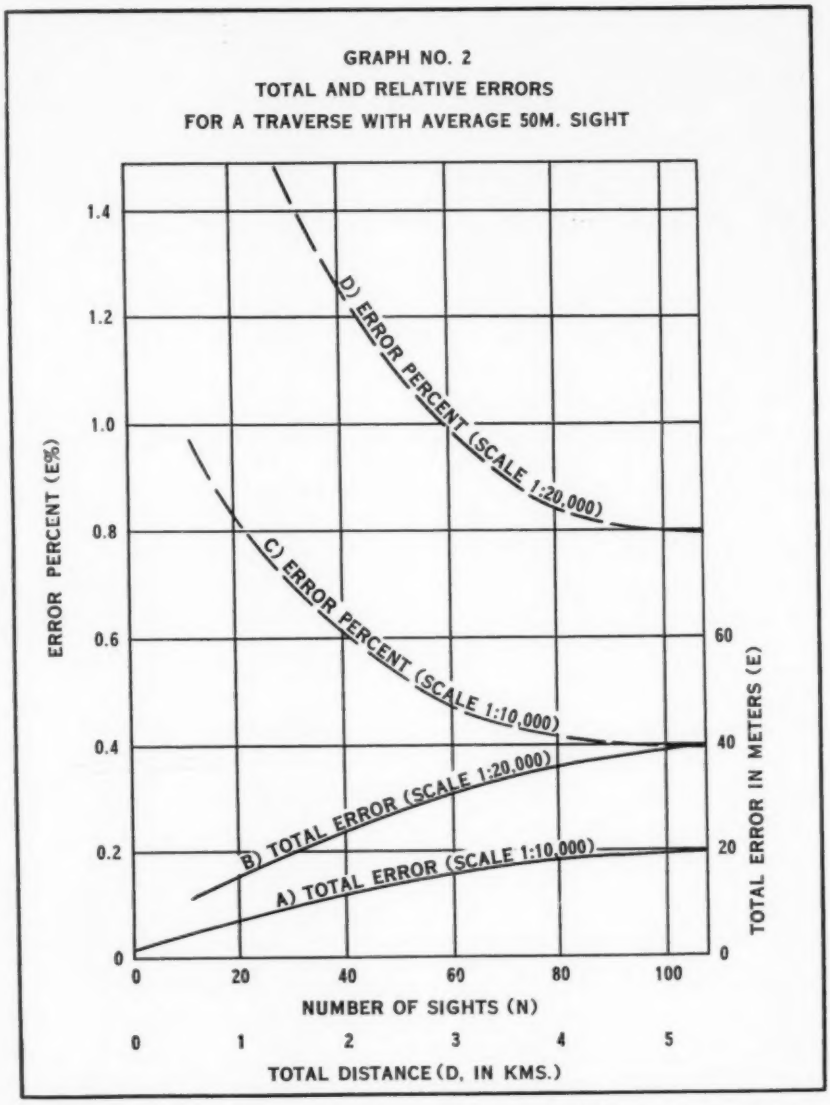
$$E \text{ (percent)} = \frac{(e_d \sqrt{n})100}{D} \tag{IX}$$

in which e_d may be taken as the probable error (see Graph No. 1) for the average sight distance in the traverse.

VERTICAL ERROR

The probable angular error for a single sight with an ordinary plane-table alidade may be expressed by the following formula, assuming for the level a sensitivity of 60 seconds per division, a vernier approximation of 1 minute, and probable errors of 1/4 division and 1/2 minute in the level and arc readings:

$$e_a = \sqrt{\left(\frac{60}{4}\right)^2 + \left(\frac{60}{2}\right)^2} = \pm 33'' \tag{X}$$



Now, taking into consideration the angular and the distance errors, and using the formula which utilizes the partial derivatives for the error in a general expression of the form $x = A_1 \times A_2 x \ldots A_n$, i.e., according to Professor Rayner's method[8]:

[8] RAYNER, W. H.: Advanced Surveying, *Van Norstrand Co.*, 1941, New York.

$$e_x = \sqrt{\left(e_1 \frac{\delta x}{\delta A_1}\right)^2 + \left(e_2 \frac{\delta x}{\delta A_2}\right)^2 + \cdots + \left(e_n \frac{\delta x}{\delta A_n}\right)^2} \qquad \text{(XI)}$$

the writer found that the theoretical probable error in elevation for a single sight with the planetable is given by the expression:

$$e_h = \sqrt{e_d^2 \sin^2 a + \sin^2 e_a \cos^2 a D^2} \qquad \text{(XII)}$$

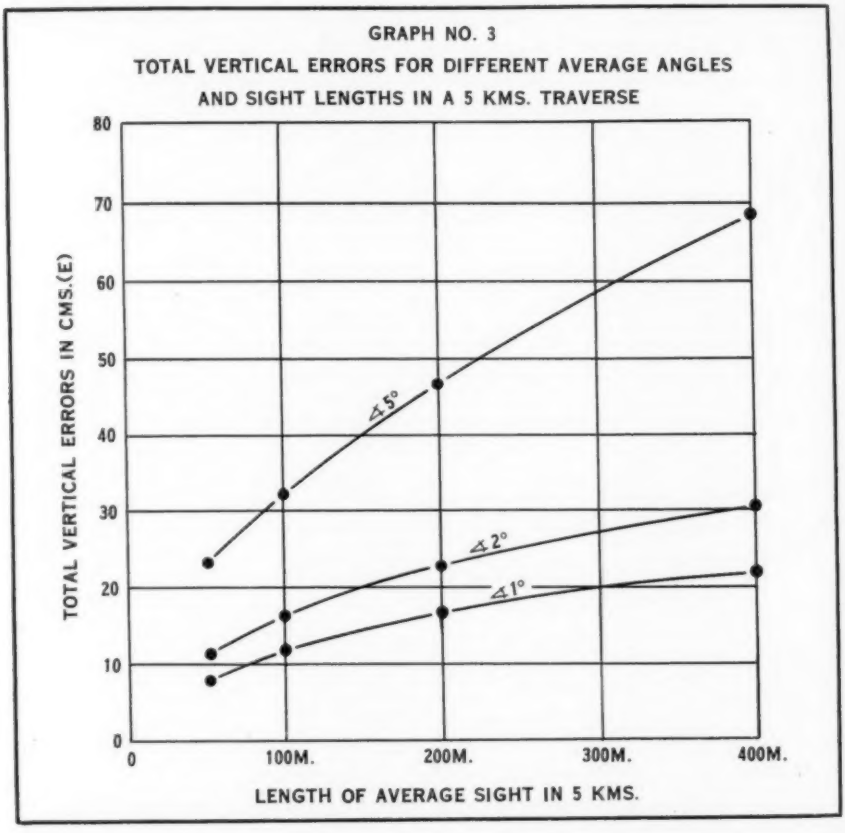
where a represents the vertical angle.

Using the above value of e_h as the probable error for the average sight distance in the plane-table traverse, the total vertical closure error is given by the equation:

$$E = e_h \sqrt{n} \qquad \text{(XIII)}$$

Graph No. 3 has been constructed on the basis of equations (XII) and (XIII) for a traverse of 5 kilometers.

Again, as in the case of the horizontal error, the theoretical analysis yields for the vertical error values which are too small in comparison with closure errors usually obtained in actual surveying. This is true even if these results are com-



pared with closures secured in using the transit-stadia method, as given in Professor Johnson's graph.

A possible explanation for this discrepancy may be found, in the writer's opinion, in three main factors not included in the preceding formulas:

1. the differential refraction, which may have in leveling an effect even worse than in distance measurements,
2. the impossibility of compensating backsights and foresights in this type of leveling, as in precise leveling, and,
3. the practical difficulty of maintaining a perfect instrument adjustment throughout the traverse.

Although the preceding analysis indicates the approximate behavior of the vertical theoretical errors (very useful information for a better planning of the field work and office adjustments), since specifications for precision based upon it appear very difficult to meet in any practical work, Table 1 is offered as a better substitute for geological surveying.

TABLE 1.—*Vertical closure errors.*

Type of Traverse	Average vertical angles	*E*
Frequent sights of 800 or more m.	$> 5°$	$0.80\sqrt{D}$
Maximum sights of 500 m.	Up to 5°	$0.50\sqrt{D}$
Sights between 100 and 300 m.	Up to 3°	$0.20\sqrt{D}$

In this table, for traverses having the general characteristics indicated, the total vertical closure error to be expected is represented, *in meters*, by the product of the square root of the total distance, *in kilometers*, by the corresponding coefficient.

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Application of Two Relative Relief Techniques to an Area of Diverse Landforms: A Comparative Study

By ROBERT B. BATCHELDER

GRADUATE STUDENT ASSISTANT, DEPARTMENT OF GEOGRAPHY, NORTHWESTERN UNIVERSITY

THERE ARE AVAILABLE to geographers numerous cartographic techniques which depict surface elements of the physical landscape. Types of maps often used in regional studies are hypsometric maps, landform regional maps and surface configuration maps. Each of these maps has applications to which it is especially suited. Each also possesses unique adverse characteristics which limit its effectiveness.[1] Often on hypsometric maps important surface conditions are not shown between the arbitrary conventional elevation values. Landform regional and surface configuration maps are generally effective, but boundaries delineating areas of different relief are largely subjective. Consequently, attempts to better represent surface configuration have resulted in a number of methods which use quantitative techniques in interpreting surface features.

Two methods, one less quantitative than the other, which express surface configuration in terms of relative relief are comparatively well known. Relative relief, or the difference in elevation between the low and high points of any area, refocuses topographic data by emphasizing the relation of slope to local relief and altitude.[2] Guy-Harold Smith has applied a method to the State of Ohio by which relative relief is shown by isarithms or isopleths enclosing areas of equal local relief.[3] Unsuccessful in applying Smith's method to southern New England, Raisz and Henry devised a relative relief method that imparts a quantitative classification to subjectively delimited areas of equal contour density.[4] Both methods of treating surface features appear effective in the areas in which they were applied.

In an attempt to analyze further these two methods, they are applied in this paper to a selected sample area. The presentation includes a discussion of the application of each technique to the sample area and a comparative analysis of the qualities of the two relative relief maps drawn.

FACTORS IN THE SELECTION OF THE SAMPLE AREA

The selected area is a longitudinal cross section in the State of Washington composed of five topographic quadrangles which extend eastward from the Puget

Prepared in connection with a Cartography seminar under Dr. Edward B. Espenshade, Department of Geography, Northwestern University.

[1] JAMES, PRESTON E.: On the Treatment of Surface Features in Regional Studies, *Annals of the Association of American Geographers*, Vol. 27, 1937.

[2] GLOCK, W. S.: Available Relief as a Factor of Control in the Profile of a Land Form, *Journal of Geology*, Vol. 40, 1932, pp. 74–83.

[3] SMITH, GUY-HAROLD: The Relative Relief of Ohio, *Geographical Review*, Vol. 25, 1935, pp. 272–284.

[4] RAISZ, E. and HENRY, J.: An Average Slope Map of Southern New England, *Geographical Review*, Vol. 27, 1937, pp. 467–472.

Sound lowland across the Cascade Range and includes a small portion of the Columbia Plateau (fig. 1). This section contains diverse landforms and surface

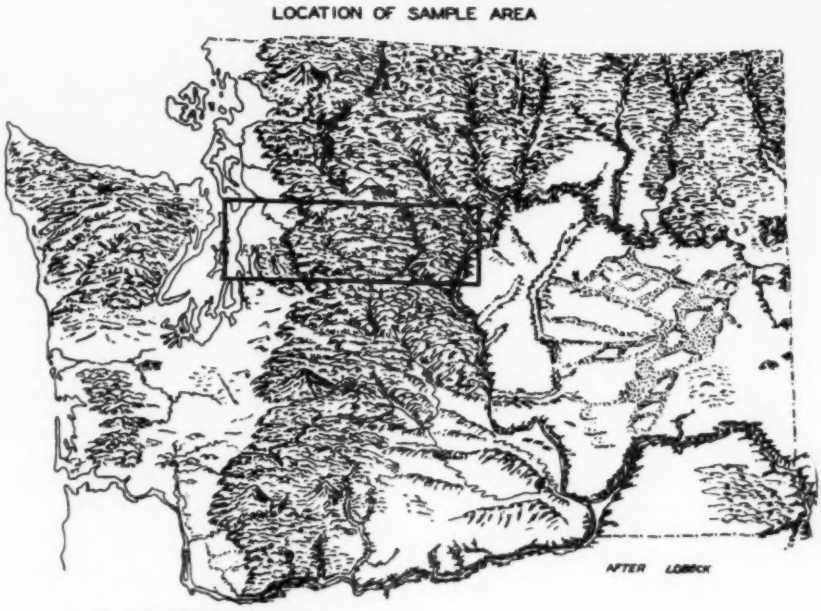

FIGURE 1

configuration in all stages of erosional development within an area of convenient size for a comparative study. In addition, existing interrelationships between the drainage features and the barrier nature of the Cascade Range have influenced to a significant degree cultural features such as population distribution, settlement patterns, and transportation routes. The topographic surveys of the mountainous areas were made, unfortunately, over a considerable period of time; however, the five quadrangles selected are at the scale of 1:125,000 and were edited about 1905.

APPLICATION OF THE METHOD OF ISARITHMS

Essentially, the method applied by Smith was as follows: Each topographic quadrangle of Ohio was subdivided into rectangular areas of approximately 25 square miles by drawing parallels and meridians at intervals of five minutes of latitude and longitude respectively. Within each rectangle the difference in elevation between the highest and lowest points, which represented the maximum relief of each unit area, was plotted. Isarithms were drawn for each 100 feet of relative relief. The completed relative relief map depicts areas of nearly the

same local relief and shows the interrelationships of the differing areas, hence, "relative relief."[5]

The application of the method employed by Smith to the selected sample area was not without difficulties. Aware of the conclusions educed by Raisz and Henry on the effectiveness of this method in depicting New England topography, a careful appraisal was made of the sample area before selecting the size of the rectangular unit area. A unit of 2.0 by 2.9 miles, enclosing an area of 5.8 square miles, was adopted. A unit of this size minimizes the tendency of narrow, deeply incised valleys to impart an unrepresentative high index value to the whole unit. Equally important, the area of the unit was kept large enough to preserve the identity of the major physical landscape patterns.

The relative relief interval of 100 feet used in the treatment of Ohio would have introduced confusing detail in the mountainous portions of the selected area where differences in local relief as great as 6,200 feet were plotted. Criteria employed in qualitatively selecting intervals were that they should:

1. Illustrate as accurately as possible areal relationships of surface features.
2. Emphasize major landforms and their boundaries.
3. Classify delineated categories in values that are significant in the interpretation of areas suitable for human occupance.

The variety of landforms within the area studied made it difficult to select intervals which would portray landforms effectively. Intervals best suited to illustrate landforms of great local relief were so large that, when applied to the hill lands and river plains of the Puget Sound lowland, the isarithms drawn had little or no significance. Conversely, intervals which effectively differentiated areas of low and moderate local relief rendered mountainous areas so complex as to obscure major surface features. The elements fundamental in the concept of relative relief, altitude, slope, and local relief, are equally important in the study of areas of potential land use. An attempt was therefore made to select relative relief intervals which would classify units of the same local relief in categories applicable to possible land-use study.

Four intervals, 100, 200, 500 and 1,000 feet, were selected. These varying intervals were a compromise which attempted to maintain detail of the plains of the Puget Sound and Columbia Plateau and also generalize to a certain degree the complex mountain features in order to emphasize major physical landscape patterns. Table 1 indicates the value of the various major categories.

TABLE 1.—*Relative Relief Values*

Landscape Pattern	*Feet*
Flat plains	0– 100
Undulating to rolling plains	100– 300
Rolling to rough plains	300– 500
Low to moderate hill lands	500–1000
Moderate to rough hill lands	1000–2000
Low mountains	2000–3000
Rough mountains	3000–4000
Rough to sierran mountains	Over 4000

The effectiveness of the map based on the size of unit and the varying relative relief intervals chosen will be discussed in subsequent paragraphs.

[5] SMITH: *op. cit.*, p. 276.

APPLICATION OF THE AVERAGE SLOPE METHOD

The relative relief method developed by Raisz and Henry differentiates areas of different average slope. This method is less quantitative but more flexible than Smith's method. Basically, average slope or relative relief was determined as follows: Each topographic sheet was subjectively subdivided into areas of approximately the same contour density. Then, by means of selected guides, the delineated areas were carefully examined and given a quantitative classification. Six guides were prepared which classified the subdivisions into average slope categories of 50, 100, 200, 300, 400, and 500 feet to the mile. The qualitative subdivision of each topographic quadrangle into categories of average slope resulted in areas of irregular size and shape. Thus, secondary features such as isolated monadnocks, deeply incised valleys, and intervales retained their relative importance and interrelationships in the physical landscape.

The rugged Cascade Range and the intricately dissected hill lands differ greatly from the more subdued, rounded topography of southern New England. Consequently, the Raisz and Henry technique had to be modified to compensate for the differences in surface characteristics which exist between the two areas. Examination of the topographic quadrangles of the Cascade Range and abutting hill lands revealed that subjective subdivision of the sheets into areas of about equal contour density would be extremely difficult and inaccurate. Therefore, accuracy in portraying the distribution and relationships of surface features in these complex areas could be preserved only by devising a more quantitative method of subdividing the quadrangles. This was accomplished by applying prepared average slope guides directly to the topographic quadrangles. Essentially a reversal of the procedure used by Raisz and Henry, this method required only one step in quantitatively measuring and classifying areas of different average slope. Subjective reasoning was limited to the selection of the average slope intervals and the degree of proficiency attained in applying the guides.

Objectives discussed in the selection of relative relief intervals for the Smith isarithm method were also applied to this technique. The average slope intervals selected are related in part to soil-slope group classifications used in soil conservation and land-use surveys.[6] The average slope values, expressed in percentages, illustrate different landforms by classifying their dominate slope relationships in significant categories as indicated in Table 2.

TABLE 2.—*Average Slope Categories*

Landform	*Percent*
Flat to undulating plains	1– 2
Undulating to rough plains	2– 5
Low to rough hill lands	5–15
Low mountains	15–25
Low to rough mountains	25–45
Rough to sierran mountains	Over 45

The values beyond 15 percent are quite arbitrary if applied to surface conditions in other areas, and possible adjustment of these values might be advisable.

[6] NORTON, E. A.: Soil Conservation Survey Handbook, *U. S. Department of Agriculture*, 1939, Washington, pp. 6–7.

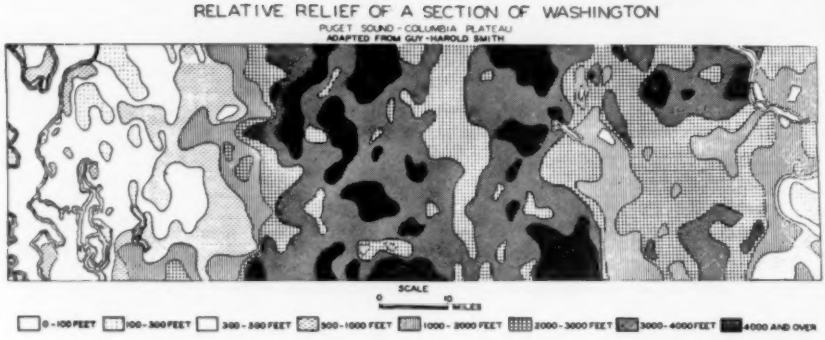

FIGURE 2

However, within the Puget Sound–Columbia Plateau area, values above 15 percent add desirable detail to the mountainous areas and emphasize slope conditions adjacent to drainage features (fig. 2). These categories, as selected, not only effectively depict landforms and areas of arable land, but indicate in the pattern of classified areas the degree of terrain ruggedness.

COMPARATIVE ANALYSIS OF THE TWO RELATIVE RELIEF METHODS

A comparative analysis of two dissimilar cartographic methods of depicting relative relief is possible only insofar as the effectiveness of the treatment of surface configuration in the sample area by each method can be adjudged. Criteria considered in evaluating the two relative relief maps are that they should:

1. Emphasize the general extent of the major landforms and their boundaries.
2. Possess continuity by suggesting the interrelationships, alignments, and transitions among the major landforms.
3. Identify major secondary surface features, such as large river valleys.
4. Be of value in general land-use interpretation.

COMPARISON OF THE REPRESENTATION OF INDIVIDUAL MAJOR LANDFORMS

The relative relief map produced by Smith's isarithm method clearly identifies the three major physiographic divisions of the sample area (fig. 2). The extent of the Puget Sound lowlands, the Cascade Range, and the Columbia Plateau, each covering approximately a third of the sample area, can be estimated on initial inspection of the map. Moreover, the different landforms within each physiographic division are identifiable, and their general extent and boundaries are clearly shown.

In contrast, the relative relief map drawn by the Raisz and Henry technique possesses a lesser degree of clarity and simplicity than the isarithm map, owing to the inclusion of considerable detail of surface conditions (fig. 3). The location and extent of the three physiographic divisions are clearly shown, but closer inspection of the map is necessary to identify the major landforms. In the plains of the Puget Sound lowland and the Columbia Plateau, the general extent and boundaries of the different landforms are effectively portrayed. However, in the hill lands and mountain areas the landform boundaries are obscured. Both

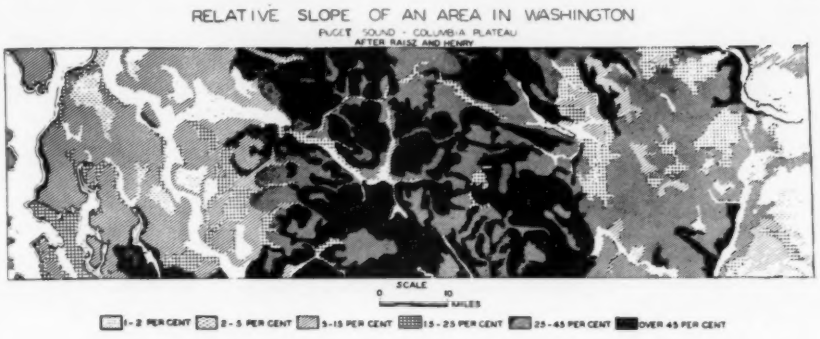

FIGURE 3

the isarithm and average slope techniques effectively subdivide the sample area into the three major physiographic divisions. The former method, however, is more effective in emphasizing the major landforms and in more clearly portraying their general extent and boundaries.

COMPARISON OF INTERRELATIONSHIPS AMONG MAJOR LANDFORMS

The term "relative relief" in its broadest concept may be interpreted as the elevations or inequalities, collectively, of the land surface. In this sense, the relative relief map should denote continuity of major landforms by portraying the interrelationships, transitions and alignments of them. Smith's map produced by the isarithm technique expresses these qualities better than the Raisz and Henry map in the selected area.

The isopleth characteristics of Smith's method impart to the relative relief map through quantitative measurement and interpolation, a partially abstract and generalized treatment of surface configuration. Consequently, the interrelationships among the major landforms and physiographic divisions are emphasized, whereas the basic elements of the surface configuration are inferred with difficulty (fig. 2). Isarithms delineating areas of different local relief have absolute values. Therefore, changes from plains to mountains are represented on the map by a series of isarithms which are intermediate in value and separate areas of low and high relative relief. The transition of major landforms from the Puget Sound lowland to the Columbia Plateau is, therefore, effectively portrayed. The general north–south orientation of the large relative relief categories parallel to the axis of the Cascade Range is recognized easily. Thus the integrated continuity of the isarithm relative relief map presents a dovetailed representation of the transition of major landforms and the regional relationships among the physiographic division of the area studied.

Inherent in the Raisz and Henry chloropleth technique are characteristics that are diametrically opposed to those of the Smith method. The average slope map tends to emphasize the interrelationships between slopes and major secondary features, which, in turn, obscure major landform continuity and alignments (fig. 3). In mountainous areas, for example, slopes of 25–45 percent are mapped as abutting valley floors having slopes of 1–2 percent. This departure from reality occurs because the intervening slope lands cover very small, narrow

areas which are omitted in the construction of the map. Consequently, the continuity of a major landform is broken abruptly by a secondary surface feature. The repetition of similar breaks results in the mountain mass and adjoining hill lands appearing as large badly dissected areas with numerous axial directions. Because of this lack of continuity, the map also fails to portray effectively the general north–south orientation of the Cascade Range. Moreover, the foothill area bordering the western flank of the mountains appears as a complexly dissected zone of secondary surface features. However, the Columbia Plateau and the western plains of the Puget Sound lowland are represented effectively except where in the latter area the large river valleys disrupt the over-all continuity of the plains to a slight extent. The limitations of the average slope map are the result of the irregular, unequal areas of the choropleth approach. They are sufficient to obscure the alignments and transitions of the major landforms by the inclusion of considerable detail of surface features, thereby weakening the broad continuity of the map.

COMPARISON OF MAJOR SECONDARY FEATURES AND THE EASE OF INTERPRETATION OF LAND USE

The choropleth qualities of the Raisz and Henry technique retain the identity of secondary surface features, depict the interrelationships between slopes and individual surface features, and effectively subdivide and classify slope areas suitable for land use.

The major drainage pattern of the Puget Sound–Columbia Plateau section is easily identified on cursory examination of the average slope map. An approximation as to the location of the crest of the Cascade Range can be made by tracing the Skykomish River to its headwaters (fig. 4). Moreover, the map portrays

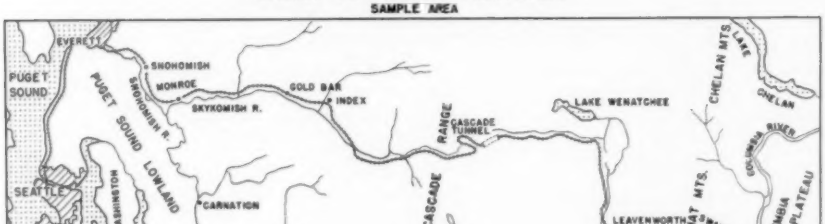

FIGURE 4

the general direction of flow of the large rivers; therefore, the alignment of the secondary features and the orientation of the mountain range can be interpolated. With a more detailed examination of the map, individual surface features, such as erosional remnants or precipitous slopes, can be located and identified—note the hill jutting above the alluvial plains in the extreme lower course of the Snohomish River southeast of Everett (fig. 4). In the identification of individual secondary features, it must be remembered that both steep slopes

and narrow, incised valleys may be represented on the map by the "over 45 percent" pattern. An illustration of this possibility occurs where "over 45 percent" slopes rising from the west bank of the Columbia River are the precipitous flanks of the Entiat Mountains, whereas the narrow, hooked "over 45 percent" pattern extending westward from the west bank of the Columbia River, near the southern margin of the map, is the canyon of the Swakane Creek (fig. 4). The ability to read readily from the average slope map major secondary surface features also enables the user to determine to some extent the degree of terrain ruggedness.

The modifications of the original Raisz and Henry average slope guides used in classifying the subdivisions of the topographic quadrangles were made in an attempt to reclassify average slope categories in order that delineated areas would better interpret the physical landscape in terms of land use potentialities. The modified technique appears successful in depicting major areas of similar slope characteristics suitable for settlement and agriculture. The high correlation of these major slope areas (slope categories 1–2, 2–5 and 5–15 percent) with population distribution and settlement patterns is verified by comparison of the average slope map to the U. S. Geological Survey topographic surveys of the sample area. The relatively flat alluvial valley floors of the major streams in hill land and mountain sections suggest probable farming areas and settlement. East of the Cascades, for example, only two level areas of any considerable extent can be easily identified as being suitable for human activity. These areas coincide with the Lake Wenatchee farming and resort area and the large apple region of the lower Wenatchee River Valley. In addition, narrow east-west valleys which are transverse to the mountain range are represented and might be routes of transportation, for example, the route of the Great Northern Railroad (fig. 4). Further examples of the correlation of the physical and cultural features of the selected area are evident from comparison of the average slope map to the topographic quadrangles.

In contrast, the partially abstract continuity and broad regional qualities of the Smith relative relief map largely preclude the emphasis of major secondary surface features. The categories of the map prevent any direct estimation of slope and, therefore, any significant evaluation of land use potentialities. These deficiencies are inherent limitations of the isarithm technique. A cursory comparison between the cultural and drainage features of the selected area and the relative relief map is sufficient to show that the drainage pattern is lost by this technique. Only the extreme lower course of the Snohomish River is represented on the map.

In the mountainous portion of the map a continuous north-south area of 2000–3000 feet relative relief is flanked on the east and west by areas of 3000–4000 feet of relative relief. It is important to note that the 2000–3000 foot category is the crest of the Cascade Range. There is a tendency to interpret the crest as a valley because the pattern of the lower mountain slopes on either side is represented by a greater relative relief value. The map is correct, however, because the crest is actually an area of lesser relative relief than the mountain slopes. Within the mountainous area are enclosed detached categories of 4000 feet relative relief that suggest mountain peaks jutting above the surrounding landscape. In reality, these areas may be of lower elevation than adjacent areas, but have greater relative relief owing to deeply incised streams. The illusion of mountain peaks would have been lessened if the relationships between these detached areas and

drainage features were expressed by the map. Likewise, in the other relative relief categories, there are enclosed areas of lesser or greater relative relief which may be misinterpreted. What appears to be a mountain may be a valley or a steep slope. Conversely, a valley with steep slopes may suggest an isolated mountain peak. In addition, if a secondary surface feature is correctly interpreted from the map, only fragments of the whole can be identified because the alignment and continuity of secondary features are completely lost in most cases. There is, for example, no indication of the Columbia River.

This weakness in depicting secondary features materially limits the use of the map for evaluation of areas for human occupance. In addition, the absence of absolute slope values prevents direct identification of areas suitable for agriculture and other types of occupance. Only indirectly may slope be inferred through relationship of the relative relief values to distances within the unit areas. These two limitations largely preclude the use of the map in the comparison of major physical and cultural patterns.

CONCLUSION

The comparative study of the treatment of surface configuration in the area of diverse landforms has disclosed certain advantages and disadvantages of each technique. It should be realized that each of these methods was originally applied to areas of surface configuration different from the one under study. Although they may have provided an effective treatment of surface features on the basis of the criteria used in this paper in the original area, neither technique provides a completely satisfactory treatment of the selected area.

In brief, the inherent cartographic qualities of the isarithm method employed by Guy-Harold Smith stress major landforms and their general extent and boundaries. Through partially abstract quantitative measurement of relative relief units, the map accurately depicts continuity and interrelationships among the major landforms and physiographic divisions of the landscape. On the other hand, in the isarithm map the pattern of major secondary surface features is lost. Also, the relationship of slope to surface configuration is only indirectly inferred; therefore, generalizations of areas of potential land use are necessarily very broad and vague.

The advantages and disadvantages of the Raisz and Henry method are almost opposite to those of the Smith isarithm method. In the average slope map, major secondary features are emphasized to the extent that the considerable detail of surface characteristics obscures many significant regional relationships of the physical landscape. The map effectively represents the interrelationships among slopes, secondary features, and areas of potential land use. Surface configuration is portrayed more nearly as it actually appears in the field. The average slope map, therefore, is especially adapted to evaluation of major secondary characteristics of the selected area.

An appraisal of the treatment of surface configuration by the two relative relief methods must be confined to the area under study. Further experimentation in other areas is required before a fairly comprehensive evaluation of the possibilities of the two techniques can be judged. However, it is felt that the Raisz and Henry average slope technique more effectively portrays the complex physical landscape of the selected area, where major secondary features and slope relationships assume more importance than they might in complex areas elsewhere.

Printing Papers

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PAPER is a matted or felted sheet of minute vegetable fibers formed on a screen from a water suspension. These vegetable fibers are composed of a substance called cellulose having the formula $C_6H_{10}O_5$. In general, the plants used in pulp and paper making may be divided into three major classes as follows: (1) seed hair fibers, (2) wood fibers, and (3) stem (bast) fibers.

METHODS OF PULP PRODUCTION

1. *Rag Pulp*

Cotton reaches the paper mill in the form of rags. The two main sources of supply for rags are new cuttings from the textile and garment factories and old rags collected from households. The first step in preparing rags is generally dusting or thrashing. After this dusting the rags are sorted into the various arbitrary grades maintained at the mill. During this sorting, foreign materials such as buttons, buckles, hooks, pieces of wood and colored papers are removed. The next step is cutting the sorted rags into pieces 2 to 4 inches square. After cutting, the rags are given a final dusting and then conveyed to the boilers.

The object of the boiling process is to remove the grease, loosen the dirt and other impurities so that they may be easily washed out, and to destroy the coloring matter. The chemicals used in cooking the rags may be caustic lime or caustic soda. After boiling, the rags are dumped into washing engines which remove the alkali from the stock. After washing, the stock is subjected to bleaching with calcium hypochlorite. The stock is then washed to remove the chemicals and placed in drainers to allow the water to drain from the stock. It is permitted to remain there until used for manufacturing the paper.

2. *Wood Pulp*

Wood is converted into pulp mechanically and by chemical treatment.

Ground wood pulp.—Ground wood pulp, as its name implies, is manufactured by grinding the wood logs against a huge revolving grindstone which separates the wood into individual fibers or bundles of fibers. Because of this method of manufacture, the pulp contains all of the materials that were originally present in the wood including the lignin and pitch. The ground wood process and ground wood pulp are frequently known as the mechanical process and mechanical pulp.

In general, ground wood pulp is used only in the cheap, short life grades of paper in which permanence of color or of quality are relatively unimportant.

Chemical wood pulp.—In the production of wood pulp by chemical treatment three processes are used, namely: sulphite, soda pulp, and sulphate. The sulphite process by which sulphite pulp is produced from wood chips consists essentially of cooking the chips with calcium bisulphite in an excess of sulphurous acid which dissolves the non-fibrous substances present in the wood, yielding

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sulphite pulp. The sulphite process derives its name from the bisulphite used as the cooking acid. The process is used principally on coniferous wood. Sulphite pulps are long fibered and enter into the manufacture of writing, bond, ledger and index papers.

In the production of soda pulp, the chips cut from such trees as birch, beech, and poplar are digested in caustic soda solution. Soda pulp is a soft short-fibered pulp without much strength. It, therefore, does not make strong paper. It is commonly used with sulphite for imparting bulk, opacity, and uniform formation to printing papers.

The sulphate process of producing pulp is actually a modification of the soda process. Instead of using sodium hydroxide as in the soda process, sodium sulphate is used in cooking the wood. The woods chiefly used are pine, hemlock, fir, and poplar. The discoverer of the process found that the pulp produced by this process was exceptionally strong and he, therefore, called it "Kraft" which in the Swedish language means "strength."

Because of their long fibers and great strength, kraft pulps are used in the manufacture of brown grocers bags, wrapping, envelope and gummed tape. They are also used quite extensively where absorbency is important, such as paper toweling.

3. *Stem (Bast) Pulp*

Flax pulp.—Linen is the fiber obtained from the flax plant which is cultivated in France, Ireland, Belgium, Holland, Russia, Canada, and the United States. Generally, linen fibers come to the paper mill in the form of linen cloth where it is processed similar to cotton cloth in the production of linen stock.

Hemp pulp.—Many plants yield fibers to which the name hemp is given. There is the Italian hemp, Manila hemp, and sisal hemp. The hemp that is used in paper making usually comes from old ropes. When these ropes reach the mill, they are cut, and subjected to the same treatment as rags. This fiber goes into the manufacture of paper sacks; namely, flour sacks and sacks for cement, lime, and plaster.

Jute pulp.—Jute fiber comes from the stem of the jute plant in India. It reaches the paper mill in the form of old sacking and burlap and is used in the manufacture of wrapping paper, tag stock, and folders. The preparation of the pulp is, in general, similar to that of rag stock.

Sugar cane (Bagasse) and corn stalk.—The stalks of both sugar cane and corn have been proposed as possible sources of cellulose and have been tried out in the production of pulp several times. They are first run through cutters and then cooked with caustic soda, washed and bleached. The low yield of pulp from the dry stalks together with the fact that they produce very weak and extremely dirty paper make these materials unsuitable for paper making.

Straw pulp.—Straw used in paper making includes the stems and leaves of the various cereals. Wheat and rye straws are the best. They give the stiffness desired in corrugating paper. Oat and rice straws are also used. The straws are cooked with milk of lime and after cooking, the pulp is washed and is ready for use.

Esparto pulp.—Esparto is especially suitable for book and writing papers and is used extensively in England. Esparto grass grows in Spain and Northern Africa (Tripoli). Like rag stock, it goes through the regular processes of dusting, washing, cooking, and bleaching in the production of pulp.

PAPER MAKING

The process of paper making starts with the beater. Here the pulp is mixed with all the necessary non-fibrous materials such as coloring matter, sizing materials, and in the case of book and other similar printing papers, filling materials such as clay, chalk, titanium dioxide, and sufficient water to make the stock about 5 percent. The beater consists of an oval shaped tub with steel bars fitted on a roll which rubs or brushes against similar knives in the bottom of the tub directly under the beater roll. The pulp is rubbed and split by the beater until it is frayed out.

From the beater the pulp is dropped into the Jordan tank where the pulp from several beaters is mixed. The stock is then pumped through a Jordan engine fitted with two sets of steel bars. As the pulp passes between these bars, it receives another brushing treatment. This process is called refining because it makes the stock more uniform.

From the Jordan the pulp passes to the machine chests, then through a consistency regulator where it is diluted to about one percent consistency; next into the paper machine screens where lumps and dirt are removed; then into the headbox where the flow of the stock is regulated to the full width of the screen wire. As the stock flows onto the wire, the excess water falls by gravity through the meshes of the wire and leaves the fibers matted with a water content of about 90 percent. The paper then passes over suction boxes placed underneath the wire screen and these pull out more of the water. By this time the paper is strong enough to support itself and it leaves the wire belt and is carried on felt blanket conveyors through a series of press rolls which reduce the percentage of water to about 70 percent. From here the sheet passes over 20 to 40 internally steam heated polished steel driers which drive off most of the remaining water. The water content of the paper as it passes the driers is about 4 to 6 percent.

CONVENTIONAL TYPES OF PRINTING PAPERS

Printing paper has been defined as any paper suitable for printing, such as book, offset, writing, bond, ledger, index, cover, and newsprint.

Book Papers

Book papers are classified as coated and uncoated. Coated papers are made by coating the base sheets with clay and bound with adhesives such as casein, starch, and glue. It may be coated on one or both sides and calendered to various degrees of finish ranging from a dull matte to a high gloss. They are divided into two classes: brush coated and machine coated. Brush coated paper is made by coating paper subsequent to the manufacture of the base sheet. This is the paper commonly known as "coated."

Machine coated paper is made by applying a coating to the paper during manufacture at a point part way through the drying process. It is of comparatively recent origin, but is fast replacing supercalendered paper in magazine printing. The best results with machine coated papers on web presses are obtained with heat-set inks. Standard inks are used on sheet-fed presses. Both kinds of coated paper are used in magazines, books, pamphlets, folders, labels and brochures where fine halftone illustrations are required.

Uncoated book paper is also used in magazines, books, labels, pamphlets, folders and brochures where high quality halftone reproductions are not re-

quired. This class of paper is made in antique, eggshell, machine, English, and supercalendered finishes.

Offset Printing Paper

The most essential qualities required in paper for offset printing are a low degree of expansion or contraction when exposed to varying atmospheric conditions of moisture. It should possess cleanliness, freedom from surface fuzz, and be free from the tendency for the surface to stick to the rubber blanket during printing.

Offset papers should be free from lint or loose particles which tend to lift or pick under printing conditions.

Since in the offset process the ink transferring surface is a moistened rubber blanket, it is desirable to have a paper sheet which is not unduly sensitive to water. For this reason, properly sized paper is usually used. Offset or lithographic ink is relatively concentrated, and quite tacky. When the tacky film of ink is transferred from the rubber blanket to the paper, a pulling action or sort of suction is exercised upon the surface of the sheet. To resist this force, it is necessary that the surface fibers be very firmly bound together. This is usually accomplished by the utilization of such binding agents as starch or sodium silicate applied in the form of either external or internal sizing during manufacture of the paper. Offset papers are usually also surface sized with starch, giving further protection against the accumulation of fuzz on the blanket, and reducing the picking of the paper surface during the printing process.

The offset process employs acid etches and water on the press plate. For this reason, the acidity of the paper does not appear to have an important bearing on its operating properties. However, highly alkaline papers, such as those containing calcium carbonate or calcium sulphite, as fillers, would chemically react with the acid etches to cause serious foaming and scumming on the press plate. Papers containing carbonates are, therefore, most unsuitable for use in this process of printing.

A good offset paper for multicolor printing should show but little tendency to expand or contract under normal variations in atmospheric conditions. This characteristic is necessary to insure good press production and register.

Writing Paper

Writing paper must be suitable for pen and ink, pencil, typewriter, and printing. The most significant class property is good writing surface.

Bond Paper

Bond is a grade of writing or printing paper originally used where strength, durability, and permanence were essential requirements, as in bonds and legal documents. Its use has extended into other fields, such as business letterheads and forms, where strength and permanence, though important properties, are not so essential. Although bond is a typical writing paper, almost all of it is subjected to some form of printing before use.

Ledger Paper

Ledger paper is used chiefly for leaves in ledger books. It is surface-sized to permit erasure of writing ink. Since ledgers are subjected to appreciable

wear, and are for purposes of record, the paper requires a high degree of durability and permanence. Significant properties include strength, especially tearing resistance, writing quality, and erasability. A good surface for ruling is important.

Bristol Paper

Bristol is a general term for a type of paperboard in thickness of 0.006 inch and higher. Bristols are usually required to have good writing quality and are used principally for index records, business and commercial cards.

Cover Paper

Cover paper is used for the outside covers as decorations or protection from handling of catalogs, pamphlets, booklets, and magazines. Some of the essential features of cover paper are folding quality, permanence of color, and a high resistance to handling and abrasion.

Newsprint

Newsprint is used in printing newspapers. The furnish is largely mechanical wood pulp, with some coniferous chemical wood pulp. The paper is machine finished, slack sized, and has little or no mineral loading. A better grade, usually supercalendered, is known as halftone or catalog news. It is widely used in newspaper supplements and mail order catalogs.

WARTIME DEVELOPED PAPERS

Certain war purposes necessitated a paper possessing high wet strength. Such a paper was required for printing maps, and training and instruction manuals for the Armed Forces for use under severe conditions not only on the ground, but also in planes, tanks and ships. It, therefore, had to resist the effects of salt, or rain water, or perspiration when carried by the sailor or soldier, as well as the grease and grime associated with motor vehicles.

High wet strength papers are produced by treatment of the paper fibers with certain synthetic resins in the beater. The application of these resins to paper fibers increases their wet strength from almost zero to about 50 percent of their original dry strength.

The Government Printing Office cooperated with the Coast and Geodetic Survey and the Hydrographic Office to develop a 50 percent Rag Nautical Chart Paper. This paper was used by these branches of the Government for printing nautical charts of supreme importance in the prosecution of the war. The paper characteristics requisite for this type of printing are: (a) minimum expansion and contraction to permit the register of four or five colors when printed by the offset process; (b) good erasing quality permitting corrections to be made with India ink directly on the chart; and (c) durability, since such charts must be handled and folded frequently.

ENDURANCE OF PAPER

There are two terms which are used in connection with the endurance of paper; namely, permanence and durability. Permanence is the resistance of a paper to deterioration due to chemical action which may result from impurities in the paper itself or agents from the surrounding air. Durability is the resistance of a paper to destruction because of handling and continual usage.

The higher the purity of the paper, the greater will be its permanence. The higher the strength of the paper, the greater is its durability. High acidity is detrimental to the life of paper. Excessive rosin used in sizing tends to produce yellowing and deterioration of the paper when exposed to light.

The permanence of paper must not be confined to its quality alone. Storage conditions must also be considered. Disintegration is greatly intensified when paper is stored in acid atmospheres. Paper fibers are also affected by the prolonged action of light or high temperatures. It is recommended that permanent records be stored under controlled atmospheric conditions of 50 percent relative humidity and 70 to 75 degrees F. temperature. If means for controlling atmospheric conditions are not available, the paper should be stored under normal atmospheric conditions free from air polluted with sulphur dioxide.

EFFECT OF RELATIVE HUMIDITY ON PAPER

Paper, being composed of a felted mass of minute vegetable fibers, is hygroscopic; that is, it absorbs or gives up moisture with every change in the relative humidity of the surrounding atmosphere. This causes expansion or contraction of the paper, thereby increasing or decreasing its size, and resulting in improper register in color work.

Curl in paper is due to the tendency of the paper to come to equilibrium in moisture content with that of the surrounding atmosphere. Curled paper causes serious difficulty in feeding the stock through the press.

Wrinkling may be due to a sudden change in relative humidity resulting in stresses set up in the sheets which tend to acquire equilibrium with changing atmospheric conditions.

The edges of paper stacked in piles may become wavy, especially during the summer months when high relative humidities exist in the pressroom or warehouse. This is due to the fact that during the increase in relative humidity, the edges absorb moisture while the moisture content of the major portion of the paper remains unchanged. The edges, therefore, increase in length and are restricted from a uniform expansion by the body of the sheet. Localized strains thus set up result in the formation of wavy edges.

"Tight edges" in sheet stock are the result of conditions opposite to those causing wavy edges. When the surrounding atmosphere has a relative humidity lower than that of the pile of paper, the edges of the paper dry out and shrink.

The friction caused by the passage of paper through the printing press generates static electricity. It develops when paper is used in an atmosphere of low relative humidity generally below 35 percent. Static is responsible for sheet feed hang-ups, offset, failure of joggers to function, and clogging of folders.

PAPER CHARACTERISTICS REQUIRED FOR GOOD PRINTING

The most important paper characteristics from a printing standpoint are surface finish or smoothness, ink receptivity, porosity, surface strength, opacity, formation, thickness, color, resistance to fluffing and dusting, absence of abrasive particles, and general appearance.

Smoothness

Smoothness is one of the most important properties for rotogravure and letterpress printing. These processes require a smooth surface in the paper to achieve

closest contact with the printing surface without the application of abnormal pressure.

Ink Receptivity

Another demand which printing makes upon paper is ink receptivity. It may be described as the paper's ready capacity to accept the transfer of inks from printing surfaces. The amount of ink necessary to attain a particular degree of color intensity in printing is related to both the paper and the ink. It should be limited to the minimum that will give the desired result. In general, the smoother and less porous the paper, the less ink will be required.

Porosity

Surface porosity is a quality in paper demanded particularly by offset printing. Since there are practically no recesses in the rubber blanket of the offset press, such as occur between the letters and the halftone dots on the letterpress plates, the ink must enter the surface capillaries of the paper or be squashed out with a resulting fill-in of type and halftone dots, impairing the appearance of the impression.

Surface Strength

Surface strength or resistance to picking is another important quality. The surface strength of paper is its resistance to separation of coating or fibers from the surface of the sheet. Paper is said to "pick" when coating, fibers, or small portions of the paper itself separate from the body of the sheet while it is being printed. Defective coated paper picks because the adhesion of the ink to the coating is greater than the adhesive power of the coating for the base paper, or because there is insufficient bonding strength in the base stock to prevent its splitting. Picking is not always due to a weakness of the coating material, but may be caused by the use of too tacky an ink. If such is the case, this tackiness must be reduced. Too heavy impressions during printing may also crack the surface.

Opacity

Printing demands paper having a high degree of opacity, especially when halftones or solids are printed on one side of the sheet, with type or light printing on the other side. Deficiency in opacity is responsible for "show through" of the printing, which interferes with legibility. Lack of opacity is often blamed for the faults of another culprit named "strike through." This is a sort of twin brother but has a different character. "Strike through" is caused by too deep penetration of the oil vehicle of the ink into the paper fibers, causing the printing to become visible from the opposite side of the sheet. The use of paper fillers, such as titanium dioxide and calcium carbonate, have added materially to the opacity of modern printing papers.

Formation

A closed and uniform formation is an essential item in good printing papers. Without this, regardless of other paper qualities, only inferior printing can be done. An open, or "wild formation" as it is normally called, is often attended by thick and thin, as well as hard and soft spots. The denser spots, where the fibers have clumped together, will act as "bearers" on the printing plate and reduce the printing pressure on the thin spots. When this is the case, the ink

will be unevenly transferred and unevenly absorbed, resulting in a mottled and spotty appearance of the printing.

Thickness

Lack of uniformity in thickness of paper affects the uniformity of the printed impression and also causes differences in the bulk of bound books.

Color

Variation in color of printing papers is not only encountered among shipments from different mills but sometimes occurs in the same shipment. Difficulties which arise from variation in color of paper cannot be corrected in the pressroom. On a long-run job, it is usually necessary to supply the pressroom with paper taken from different shipments. If the color of successive lots of paper differs and the ink remains the same, there will be a variation in the tone value of the printed work, since the ink is adjusted to the color of the paper first used.

Flaking and Dusting

Flaking and dusting of paper surfaces occur when materials such as clay or other fillers, or the fibers themselves, are separated from the paper surface by friction or are left on the ragged edges of sheets cut by dull knives. The fibers and dust rise in the air over the press and settle on the rollers and printing plates, resulting in mean little islands, black specks of ink surrounded by blank white rings on the printed surface. These materials work back on the rollers into the ink fountains and so contaminate the ink that it is at times necessary to throw it out, wash up, and start all over again.

Absence of Abrasive Particles

Abrasive materials are occasionally found in paper, sometimes occurring in the filler and sometimes being carried in by the water during the manufacture of paper. Whatever their source may be, they play havoc with letterpress plates, wearing down the copper plates and halftones. They are especially objectionable in rotogravure printing as they scratch the polished non-printing surface of the copper cylinder causing fine hairlines to be printed in the non-printing areas.

General Appearance

One of the most objectionable defects in paper is an unsatisfactory general appearance due to dirt. Examination of the dirt generally found in paper reveals that it consists chiefly of dark colored mineral and resinous specks, shives, or pieces of wood. Metallic particles are sometimes found embedded in paper. Slime spots, colored fibers, or crush caused during the calendering process give to the paper a mottled appearance.

CONCLUSION

In conclusion, suffice it to say that printability is not a solo property of paper, but a property of conditions. In other words, printability cannot be entirely built into the paper by the manufacturer. It results from a proper correspondence of certain requirements of the printing process, the kind of ink, and the paper itself. A coordination of all the factors involved is necessary to the desired result and it is this fact that makes printing both an art and a rapidly growing science.

Grave Relocation in TVA Reservoir Areas

By T. L. BENNETT

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GRAVE RELOCATION PROBLEMS encountered in a reservoir preparation program ordinarily attract little attention from an engineering point of view, but often constitute some of the most delicate to be dealt with. When a dam is being constructed which will impound water in an inhabited river valley it is probable that a considerable number of cemeteries will be affected by the reservoir and, possibly, by incidental construction activities. Looking back to the beginning of work in 1933 on the Tennessee Valley Authority's first project, Norris Reservoir, it is felt that the methods that have been developed for meeting and resolving difficulties attendant to relocating several thousand graves during these 15 years have contributed to the cumulative experience of the engineering profession.

When in the early days of the Authority's existence the engineering staff was engaged in appraising the extent and diversity of the job to be done, it was not long in finding that there were some three hundred cemeteries in the area below and adjacent to the proposed Norris Reservoir pool level. Although it was not assumed that all of these cemeteries would be affected, extensive investigations would be required to find out. Furthermore, and more important, there were no legal or engineering precedents for dealing with a problem of this type and magnitude. On the other hand, probably no other location could have been selected which would have necessitated study of the problem in as many of its kaleidoscopic aspects. Although, at first glance, the work might not appear to fall entirely within the scope of surveying and mapping activities, most of the related investigations and operations parallel those activities more closely than other engineering functions. Consequently, responsibility for this phase of reservoir preparation was assigned to the Maps and Surveys Branch of the Authority's engineering department.

The region proximate to the proposed reservoir, largely populated by descendents of pioneer settlers, was one in which deeply rooted traditions and customs were characteristic, and it was only natural that the residents maintained a strong feeling of reverence for their dead. From the point of view of the TVA staff the whole problem was approached as one arising from a regrettable necessity. Thus, when this first grave relocation program was completed with but little criticism and with the general good will of the community, those responsible for initiating and carrying it out felt that the job could be reviewed with a justifiable feeling of satisfaction. The foundation of study, investigation, and experience laid during the execution of the work in the Norris area has furnished the basis for the policies and procedures since followed on all of the Authority's dam and reservoir projects.

Three cardinal principles underlie the grave relocation program for any reservoir, even though detail criteria, of necessity, vary from project to project. First, state laws and regulations applying to the disinterment, transportation, and reinterment phases of the work are meticulously observed; second, every reasonable effort is made to comply with the wishes of the living relatives in connection with all matters pertaining to grave relocation; and third, all personal

dealings and all actual removal operations are conducted with full consideration for the feelings of the living relatives with respect to their dead. Pursuant to these general maxims, the Authority performs all removal work with its own forces and at its own expense; obtains all necessary permits (legal and personal) required for the disinterment and reinterment of remains; moves and replaces existing grave monuments and markers; assists cemetery trustees in selecting and planning new cemetery sites, when necessary; maintains detail records of each grave affected in any way. Arrangements are always made for relatives to witness the disinterment and reinterment, if they so desire, but general public inspection of the work is discouraged.

Graves are considered affected if they will be flooded or subject to damage by wave action, if they will be rendered inaccessible by the flooding of roads (when the costs of replacing the roads are prohibitive), or if they will be disturbed by construction activities. When it has been determined that graves in an existing cemetery, public or private, will be affected, exhaustive investigation and inquiry is made to identify the interred persons and to locate the nearest kin. Frequently, these are not easy tasks, especially when the graves are without markers inscribed with the names of the deceased. The living relatives are then visited, detail explanations are given as to the extent to which the graves will be affected and as to how the relocation operations are carried out, and they are requested to decide whether or not the graves are to be moved. When graves will only be inundated or isolated (not disturbed by construction or wave action) the relatives often request that they be left in their original locations, but in either case, they are asked to execute a clear, simply worded agreement setting out their wishes in regard to the disposition of each individual grave over which they have control. Some graves, usually in the older cemeteries, cannot be identified by residents of the community. These are not moved unless relocation is requested and authorized by cemetery trustees or responsible officials of the organization (church, association, etc.) controlling the cemetery. Infrequently, when it is necessary to move graves which will be disturbed, some types of legal authorization must be secured. If the graves are of persons of unknown identity, approval of the governing body of the county is usually sufficient authority; for identifiable graves permission must be obtained from the living relatives or a court order is required.

After a thorough reconnaissance has been made to locate all cemeteries in the reservoir area, detail surveys are made of each one which will be affected in any way. Usually, these surveys are by planetable and at a scale of 1 inch = 20 feet. The planetable sheet, when complete, shows the boundaries of the cemetery tract; the exact location of each grave and monument; the limits of wooded areas, and the locations of lone trees; 2-foot contours (1-foot in flat areas) unless the cemetery is definitely and entirely above or below the guide contour for grave removal work; elevations at each corner of the cemetery; the grave number assigned to each grave in the cemetery; and ownership of the tract and adjoining tracts. Graves are shown by standard symbols, indicating whether or not they are positively identifiable, are marked by inscribed monuments, etc. The surveyor also submits pertinent supplementary information required for preparation of a comprehensive plot, including a detail listing of the graves with assigned numbers, names, relatives, monument descriptions, and monument inscriptions. From these surveys, plats of the disinterment cemeteries are traced for use in dealing with the

relatives, cemetery officers, and county officials, and for the permanent records of the Authority.

The living relatives of the deceased choose the new locations for the individual graves in which they are interested—either in unaffected existing cemeteries or in new reinterment cemetery sites selected and purchased by the trustees or owners of the original cemeteries. When new cemeteries are established the sites can be purchased with the proceeds received from the original tracts acquired by the Authority. The Authority furnishes assistance in determining the suitability of new sites, including probings made to insure that they are not underlaid with rock within a normal grave depth.

After a new reinterment cemetery location has been selected and purchased by the cemetery officials, the TVA furnishes surveying, mapping, and planning services necessary for laying out the lots, blocks, drives, and walkways. A planetable topographic survey is made at a scale of 1 inch = 20 feet with contours at 2-foot intervals (1-foot in flat areas) which is reproduced by photostatic or photographic processes to obtain work-prints. The final layout is staked on the ground and a tracing of the cemetery tract and the layout is prepared at the same scale as the planetable sheet, 1 inch = 20 feet. In making the layout the customary east-west position of graves is observed, with the headstone to the west so that the interred faces east, except where the topography would cause such a layout to be impractical. In those cases, special permission is usually granted to vary the layout from the east-west direction to fit the topography. After reinterments have been completed the new location of each grave is plotted accurately, with the assigned number shown in the grave symbol. Listed on the plat or, if necessary, on a supplementary list are the names of the deceased; the new grave, lot and block designations; and the corresponding numbers of the original cemeteries and graves from which the removals were made. Prints of the final plat and list are furnished the cemetery officials.

If an existing cemetery is chosen by the relatives as a reinterment site a similar plat is made, but only of that portion of the cemetery used for the new graves.

It is important that the disinterment and reinterment operations be carried out under the supervision of experienced, tactful men and performed by well-trained labor. On a normal reservoir project it will be necessary to have separate disinterment and reinterment crews and, when the relocation of a considerable number of large monuments is involved, a special monument crew under the direction of an experienced stone mason. A field clerk keeps detail records of all disinterments and reinterments.

Individual grave removals are scheduled several days ahead of operations and the relatives are notified of the date on which they are to be made. Each day the crew foremen are given lists of the graves to be moved on that day. The disinterments are made in the morning and the reinterments in the afternoon.

Standard casket boxes are used for transportation and reinterment purposes unless the original casket was encased in a vault or—as some of the older caskets were—made of cast iron. The usual types of hand tools are used in removal operations and a hand hoist is employed in lifting the larger monuments. Every reasonable precaution is taken to assure that all of the work is done carefully. Upon completion of the reinterment operations all surplus earth is removed, along

with any brush or debris cleared from the site, and the cemetery is left in a neat and orderly condition.

It is unlikely that planning and directing the execution of grave relocation work will ever assume the importance of being considered a specialized field in engineering, but it can be pointed out as an example of the side lines demanding versatility, and the application of good common sense with which any engineer is likely to be confronted. Certainly, it is a side line which requires the exercise of circumspection and tact to an extent necessary in few phases of the profession, and the experienced surveyor, familiar as he is with public records and accustomed as he is to resolving problems "in the field" through personal dealings with the individuals primarly concerned, is logically fitted to be responsible for the execution of grave relocation activities.

* * *

Aerial Photography for Highway Work

HIGHWAY ENGINEERING STUDENTS at Cornell University are now following every detail of the most advanced practice of highway location methods. The increased use of aerial photographs in the field phases of engineering makes training in these problems a necessary part of every civil engineer's education.

Following a series of conferences with location engineers and officials of the Public Roads Administration, the Palisade Interstate Parkway Commission and the New York State Department of Public Works, a complete location problem based upon actual aerial surveys was selected. This location study has the step by step reality of an executed project since it is based upon the surveys and conditions attending the design and construction of sections of the Palisades Interstate Parkway (New York-New Jersey).

Starting with the specifications for aerial photography by the Aero Service Corporation of Philadelphia, the students carry through from an examination of aerial mosaics for alternate routes to a stereoscopic examination of contact prints that establishes the location of the preliminary line and curves. Using the actual contact prints, as well as ownership maps and 5 ft. contour topographic maps produced from the airphotos, right-of-way and drainage lines are established. Excavation computations based on the photo maps and checked by commission engineers are followed by a critique of the problem in which ground photographs, furnished by the Palisades Interstate Parkway Commission, are used to illustrate the various types of equipment and excavation and embankment materials encountered during construction. The active cooperation of Sam Nelson, deputy chief engineer of the commission, has made it possible for this comprehensive training to be given to undergraduate engineers. For those students desiring to concentrate on aerial surveys applied to engineering soil conditions, drainage maps, land planning and natural resources, advanced courses are available. Graduates now hold primary positions in aerial mapping programs of several of the states.—Donald J. Belcher, *Engineering News-Record*, October 27, 1949.

Instruments for Accurate Plotting

By SERGE A. EMERY
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ACCURATE plotting is necessary in many fields, especially surveying. The two instruments described permit accurate plotting on plans and maps.

ENGINEERING TRIANGLES

The first of these instruments may be called Engineering Triangles. (*See* fig. 1.) They consist of two 45°–45°–90° metal triangles of the same size. The usual length of the hypotenuse is about 8 inches and each triangle is about ⅛-inch thick. The hypotenuse of one (main) triangle is divided for a definite scale in such manner that the zero is in the middle of the hypotenuse with the division progressing outward from each side of the zero. The hypotenuse of the other (vernier) triangle is divided so as to act as a vernier for the main triangle. Zero is in the middle of its hypotenuse and there are vernier dividings on either side of zero. The other two sides of the triangle are faceted.

When working with Engineering Triangles and plotting, in scales usually used, it is possible to read directly and plot to a precision of 0.1 foot.

The triangles can be used to compute graphically the areas of any figures of three or four sides. The elements necessary for such computation can be measured with the precision mentioned above.

Rectangular coordinates and all figures which have parallel or perpendicular lines or a combination of both (e.g., houses) may be plotted or measured from plans.

Each pair of such triangles is divided for a definite scale. If it is necessary to work with another scale the new scale and new vernier can be placed over the basic scale by means of screws.

Plotting Procedure

If it is necessary to plot perpendiculars (perpendicular offsets) from a measurement (traverse) line, proceed as follows:

(1) Place a facet side of the vernier triangle on the measurement line.

(2) Hold the vernier triangle firmly with the right hand, then place the hypotenuse of the main triangle against the hypotenuse of the vernier triangle and move it with the left hand until the zeros coincide.

(3) Hold the main triangle firmly. If the perpendicular offset is above the measurement line, move the vernier triangle to the left, and if the offset is below the line, move it to the right. When the required reading is reached, mark it, using the same edge of the vernier triangle that was previously on the measurement line. Use a hard (3H to 9H) pencil which has been sharpened to a wedge-shaped point.

If it is necessary to plot definite lengths on a measurement line, the beginning of which is established and marked, proceed as follows:

(1) Place a facet side of the vernier triangle on the measurement line.

(2) Hold the vernier triangle firmly with the right hand, then place the hypotenuse of the main triangle against the hypotenuse of the vernier triangle.

(3) Hold the main triangle firmly with the left hand and slide the vernier triangle along the hypotenuse of the main triangle until its other facet edge comes to the starting point of the measurement line.

(4) Hold the vernier triangle and move the main triangle until the zeros coincide.
(5) Hold the main triangle firmly and move the vernier triangle until the required length is reached and make the mark on the measurement line.

In order to plot the next length, if the measurements are made continuously from the beginning point, move the vernier triangle until its zero reaches the next required measurement reading on the main triangle. If the measurements are not continuous, leave the vernier triangle in its position and move the main triangle until the zeros coincide and from this position move the vernier triangle until it reaches the required length. Continue to mark all required lengths until the final measurement (end of measurement line) is reached, which must also be marked.

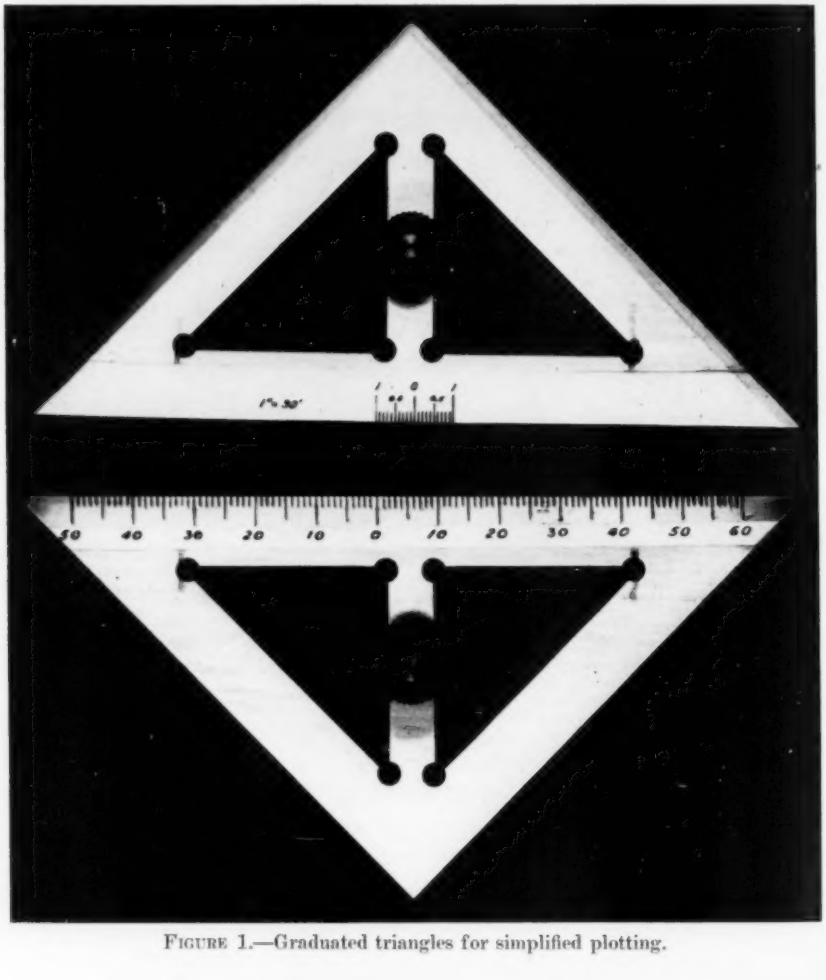

FIGURE 1.—Graduated triangles for simplified plotting.

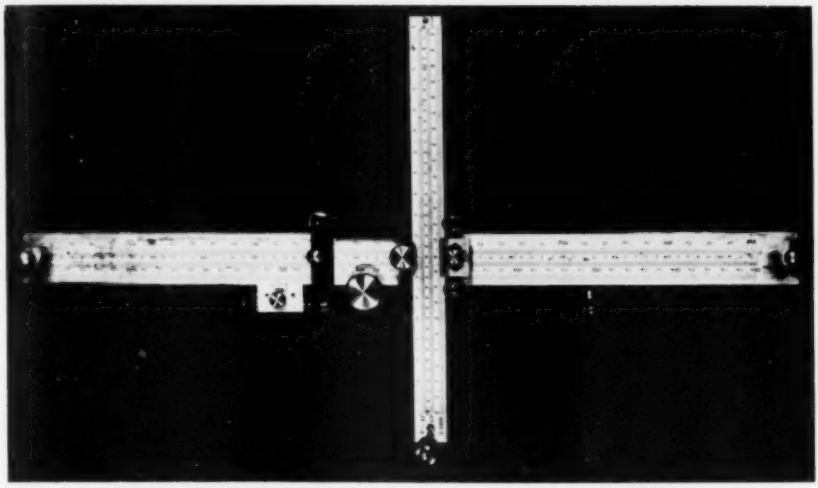

FIGURE 2.—Coordinatograph for plotting abscissas and ordinates.

SMALL COORDINATOGRAPH

The second of these instruments for accurate plotting is called the Small Coordinatograph. (*See* fig. 2.) This instrument is made of metal and is composed of a large, heavy ruler, divided for three different scales; a small, lighter ruler, which is also divided for the same three scales as the larger ruler, with an attachment on one end in which a pricker or a special magnifying glass can be placed; a movable frame which has two verniers—one for the large and one for the small ruler; and a removable arm which is used only to put the instrument in the proper (parallel to measurement line) position. On the end of this arm there is a circle on which a black cross is marked, so constructed that it is the same distance from the large ruler as is the pricker when the zero of the small ruler coincides with the zero of its vernier.

The large ruler is used for plotting plus stations or coordinates of abscissas. The small ruler is perpendicular to the large ruler and is used for plotting perpendicular offsets or coordinates of ordinates.

Plotting with the Small Coordinatograph, in scales usually used, can be done with a precision of 0.1 foot.

A hundred to one hundred fifty points per hour can be accurately plotted with this instrument.

Plus stations or abscissas and perpendicular offsets or ordinates for points which have been previously plotted can be read from maps or plans with the precision previously mentioned. This is possible by using the magnifying glass, in which there is a black cross, instead of the pricker.

The use of this instrument is especially recommended when many points need to be accurately plotted or measured on plans or maps.

Plotting Procedure

The instrument must first be placed in the proper position. The zeros of the large and small rulers must coincide with the zeros of their verniers and the

point of the pricker must be on the beginning point of the traverse or measurement line. The intersection of the black cross of the removable arm must be exactly on the line. As the instrument is now in the proper position, the arm may be removed and plotting begun.

(1) To plot the first point move the entire frame left or right by means of the largest screw until the zero of the vernier reaches, on the scale of the large ruler, the desired reading of plus station or abscissa.

(2) Move the small ruler up or down by its screw until the desired reading for the perpendicular offset or ordinate is reached. Mark this desired point with the pricker.

Proceed in this manner to plot all desired points. The screws for both rulers are constructed in such a way that precise movement is obtained.

Increased Usefulness of Topographic Mapping

PRACTICES NOW FOLLOWED by the U. S. Geological Survey have greatly increased the usefulness of the topographic quadrangle mapping of that agency. When color-separation drawings have been completed for a quadrangle, a map user in the Pacific Coast States may obtain from the Pacific Division Office of the U. S. Geological Survey, Federal Building, Sacramento, Calif., a preliminary one-color ozalid print on a scale of 1:24,000 (1 inch = 2,000 feet). These prints are very close to accurate scale and may be joined with adjacent sheets to form composite maps of larger areas.

The final maps for the valley and foothill areas are to be published in color as 7½-minute quadrangle sheets. The preliminary one-color prints (obtainable a few months before the published map is available) will be printed in a vacuum frame directly from a composite positive film made up from the color-separation negatives in such a way as to subdue the contour lines and accentuate the streams so that canal lines, for example, may be more readily distinguished from contours. The price of these prints will be 40 cents each.

Maps for the mountain areas are to be published as 15-minute quadrangle sheets, but a separate positive film enlargement of the preliminary prints will be made for each 7½-minute quadrangle. For these prints the charge will be 60 cents. Similar one-color enlargements may also be obtained from previously published 15-minute quadrangle sheets, but the cost of making the photographic enlargement must be added to the price of the prints.

The U. S. Geological Survey is rendering a distinctive service in making these preliminary map prints available to engineering, geological, mining, lumbering, and agricultural organizations and industries.

(Similar services have been afforded on mapping programs in other sections of the country. For example, on the TVA-USGS 1:24,000 mapping project in the Tennessee Valley, advance map data have been made available to users since publication began in the 1930's. Photostats are furnished of manuscripts and one-color composite prints after color-separation drafting; small index maps of reproduction availability are distributed bimonthly.—ED.)

—EARNEST A. BAILEY

Plastic Sheets in Map Reproduction

By SAMUEL SACHS

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PLASTIC SHEETS used in map reproduction, known as Vinylite, are a development of modern plastics. Vinylite is a dimensionally stable material manufactured only by the Bakelite Corporation, with some of the material being subsequently processed by other firms and supplied under their own trade names, such as Copyrite, Dyrite, Di-Noc, and Virginia Plak. Plastic sheets have been used with remarkable effectiveness in developing methods for expediting the procedures of chart and map reproduction.

The advantages of Vinylite for compilation and drafting of the base map, are now common knowledge and therefore will be omitted from this talk, with the exception of mentioning that a new Vinylite sheet for these purposes, will soon be marketed. It will be laminated with paper on both surfaces and cost less than the present plastic sheet. It will have an excellent drafting surface for India ink and will of course, retain the stability now inherent in Vinylite.

It is the less known but quite important uses of Vinylite which will be described at this time. The first application to be discussed will be that of the color proof.

COLOR PROOFS

One interesting use of the plastic sheet is the production of color proofs of maps directly from the negatives. When the edition of a map is due to be printed, it is desirable to have an advance copy for proof-reading of data and registration. On this proof the verifier indicates the changes which should be made before the final printing. Proving maps on plastic is economical, as it eliminates the necessity of preparing lithographic press plates for hand or press proving, which, because of proof changes often need to be made over. The operation of using colored inks to superimpose the plate images on paper is also avoided.

To process color proofs on plastic sheets directly from the negatives, the plastic is coated in the plate coating machine with a bi-chromated emulsion which incorporates a dye of the desired color. The plastic is then placed in the vacuum printer and, with the separation negative in position, is exposed to the arc lamps. Development is accomplished by washing with water to remove the unexposed areas. This cycle is repeated for each of the colors. Registration is perfect, furnishing the proof-reader with a facsimile of the chart, with true relationship between features, such as drainage in one color, to contours or culture in other colors.

Color proofs may also be made from positives, directly to the plastic, also by coating, exposing, and developing once for each color. However, here, the deep-etch method is used, and in addition, the developed image is each time stained with a dye of the proper color, before the resist is removed.

Proving on plastic is accomplished in less time than is required to process the press plates, and yet provides a proof of superior quality.

Presented at the Ninth Annual Meeting, American Congress on Surveying and Mapping, Washington, D. C., June 8–10, 1949.

ARTIFICIAL NEGATIVES

Another application is the artificial negative. Colors are often used in the reproduction of maps to emphasize areas, such as blue for water, gray for land, and so on. Each area requires a negative from which the tone is obtained by exposure to the press plate. A film of ruling or halftone may or may not be interposed between negative and plate at time of exposure. Flat tints, solid ruling or halftone, lend themselves admirably to the artificial negative procedure, the actual drawing being converted into the final negative.

This is achieved by placing a chemical blue line image on the plastic and using a water soluble opaque to paint in the areas which are to print on the chart. A non-actinic dye, maroon in color, is applied to the entire surface of the Vinylite; the dye being resisted by the opaque, which is then removed with water. The resulting image is a negative which will withstand abrasion and yet is amenable to corrections.

There is no photographic operation involved, nor any inconvenience of using glass. Here again the plastic sheet serves to expedite production and provide an economy in time and cost.

DUPLICATE NEGATIVES

A further use of the plastic sheet is the production of duplicate negatives, without the usual intermediate step of first making a positive. Duplicate negatives serve well, for purposes of alterations, where it is desirable not to change the original negative. Duplicate negatives are ideal for convenience in shipping and to avoid breakage of glass.

Large charts, which require two or more glass negatives for lithographic plate making, can be combined into one negative for the entire chart. If desired, several negatives may be exposed to the same area.

In making duplicate negatives on plastic sheets, the method is similar to the deep-etch process using bichromated gum, except that after development the plastic is stained with the maroon dye. The duplicate negatives are not mirror images, but read as do the original negatives. This is accomplished by exposing through the back of the plastic, using a single arc lamp, at an increased distance. Negatives made in this manner are clear and sharp, and need no painting or retouching, with the dye impregnating the plastic to form a durable negative not easily marred or scratched.

GRADIENT TINTS

Colored areas on charts are helpful in distinguishing the various features. In the construction of the aeronautical chart the standard practice is to use tints to indicate such features as water, towns, and gradients of elevations. The preparation of these tints requires a considerable amount of labor. Vinylite has made possible the development of a procedure for drafting these tints at a cost of less than 40 percent of the method which it supplanted. This efficiency is a result of utilizing the artificial and duplicate negative techniques.

Some of the highlights of the method are: (1) Several gradients are not drafted, being obtained from the adjacent drafted gradients; (2) the ease afforded the draftsman in following the blue lines which are not complicated by composite prints of the base colors, for instance, in following the contour lines no other lines are present; (3) glass is not used; (4) the operation of painting the water and town areas for each gradient is avoided; and (5) no photographic work is done.

BLACKLINE PRINTS

Another development is the blackline print on plastic sheets.

There has always been a desire to produce a print from a negative which would give definition equal to the negative and yet would be on a material which retained size. This is now being done on white opaque and transparent plastic sheets by coating with a bichromated gum to which black dye has been added. After exposure and development, there is obtained a dense black print which provides excellent copy for the camera. This procedure has an important application in the periodic revision of a map. By the time an original drawing has been revised once or twice, it usually has become poor reproduction copy. This results in a negative of inferior quality and necessitates considerable retouching. The modern approach to this problem is to paint for deletions on the existing negative and then make a blackline print, to which bluelines may be added if so desired. The new information is added by drawing and stick-up of lettering, and a new negative made.

This method supplies a perfect copy from retouched negatives for each revision, and avoids any necessity for correction of deteriorating original drawings. Each fresh print when revised becomes an original.

Another application is in increasing the limits of a chart. A blackprint is made of the existing negative and the compilation for the extended area is applied. A new negative is then made, adding a yellow non-actinic coating only to the new portion, and then using the glass negative engraving technique to match the original work.

Still another useful application of the blackprint is in those instances where map copies of the highest quality are needed for possible photographing at some future date.

Recently, a successful test was made of a new blackprint emulsion which because of its increased opacity will be most useful in making a negative from a positive, thereby paving the way for still further uses of plastic sheets.

MINOR APPLICATIONS

Thus far the major applications of the plastic sheet have been outlined; however, there are uses that have been made for minor purposes which are capable of further expansion or modification to meet the needs of a particular problem. The following are some of these uses:

Direct plate making.—Smooth drawings of maps on transparent plastic, 0.005″ in thickness, are processed directly to the plate without first making a negative or any other intermediate. This procedure requires a drawing which is unsoiled and on which the data is completely opaque in density.

Flats.—The reproduction of maps in booklet form is well accomplished by using plastic sheets for making up the flats. The negative films of the first color are assembled on a clear plastic. A second clear sheet is placed over this assembly and the films of the second color placed in register. The procedure is repeated for each additional color. At the time of plate making, a Vinylite mask is registered with each flat to block out the non-printing areas between the maps.

Golden rod paper is conventionally used for flats, requiring the cutting out of panels, leaving narrow bands of paper to which the films are fastened. Registration of colors suffers, as these bands are distorted because of the effect of humidity on the films. This of course does not occur with Vinylite.

Transfer patterns.—The use of Vinylite in the drafting of tints, for soil and similar maps, completely obviates the method which has been used for over 50 years; namely, pulling impressions from the pattern plates or stones for transfer to the gummed out plate, or at an earlier date to the lithographic stone. With the new method, the plastic, which is a window negative, is processed to the plate, the desired pattern being obtained by interposing a film between the plastic and plate at time of exposure. Nine plastics, exposed to three plates, will provide the large variety of designations currently used. Should it be necessary to remake a press plate, this could be quickly done, whereas with the transferred patterns the plate would need to be gummed out again, which would be a lengthy task.

Engraving.—Plastic sheets are readily coated, with the same yellow, non-actinic engraving ground used for the glass negative engraving procedure. Grids of large size are easily engraved. This engraved plastic sheet is then used as a negative to produce blackline prints on plastic for a number of charts.

Wet plate emulsion.—By applying the proper sub-stratum to Vinylite, it is possible to carry the sheet through the wet plate process and obtain a negative of good quality, to which the emulsion will adhere permanently.

Specialities.—There have been produced special graphs and scales on transparent thick plastic, with the image on the face or back of the sheet. The dyed image is etched into the plastic and is therefore practically indestructible.

In conclusion, it should be stated that Vinylite sheets are obtainable from one source or another, in thicknesses of 0.001″ and up. Three basic types are produced, the calendered, cast, and planished sheets; a photographic emulsion on planished sheets is also available.

For efficient application of plastic sheets to map reproduction it is highly desirable to have a knowledge of the techniques used in the various procedures and to be informed of the characteristics of the several dozen variations in finish, size, and thickness which are available, in order to select that type which is best suited to the purpose in mind.

New Surveyor Classification

THE SURVEYING PROFESSION has recently been notified officially of an elevation of status by the United States Bureau of the Census. Formerly, the Census Bureau listed surveyors under the heading of "Semi-professional Workers," along with dancers, chorus girls, sports instructors, etc. The new classification of surveyors is under the heading of "Professional, Technical, and Kindred Workers," together with, among others, architects, dentists, engineers, religious workers, physicians, and surgeons.

This matter is of considerable importance to the profession in that, under the previous listing, some governmental agencies felt required to demand competitive bids for survey work and otherwise to treat surveyors in a non-professional manner.

The change was accomplished by a campaign over a period of years by the American Congress on Surveying and Mapping. The new classification was announced to S. A. Bauer, president of the American Congress on Surveying and Mapping, in a letter dated March 21, 1950, from Dr. Roy V. Peel, newly appointed Director of the Bureau of the Census. This news should be welcomed by the entire surveying profession.

Surveying and Mapping News

Members are requested to send in surveying and mapping news items for publication in SURVEYING AND MAPPING.—EDITOR.

CURRENT SURVEYING AND MAPPING LITERATURE

MAGAZINE ARTICLES

MINING LAW IN RECENT YEARS. William E. Colby, *California Journal of Mines and Geology,* July 1949. (Deals with the origin and growth of the Federal public land system.)

GEOGRAPHICAL INTERPRETATION. Isaiah Bowman, *The Geographical Review,* July 1949. (Illustrates the capabilities of geographical interpretation drawn from Britain and the work of the geographers attached to the Ministry of Town and Country Planning.)

EARLIEST MAPS OF WASHINGTON, D. C. Leo Otis Colbert, *The Military Engineer,* July–August 1949.

A NEW NET FOR A WORLD MAP. C. B. Fawcett, *The Geographical Journal* (London), July–September 1949. (Describes the construction of a new map projection developed as a composite of the azimuthal projection modified by extensions to provide equal-area properties.)

INTERNATIONAL GEOGRAPHICAL CONGRESS, LISBON, 1949. *The Geographical Journal* (London), July–September 1949.

A SURVEYING INSTRUMENT FOR YOUR WATCH CHAIN. Thomas E. Riley, *Engineering News-Record,* August 11, 1949.

TEST FITS WORKER TO RIGHT JOB. Joseph Gambatese, *Engineering News-Record,* September 29, 1949. (Describes aptitude test for selecting draftsman for the Dravo Corporation in its Pittsburgh drafting room, and the results obtained.)

ENGINEERING REQUIREMENTS IN CONNECTION WITH LAND SUBDIVISION. K. J. Mawson, *New Zealand Surveyor,* September 1949. (Outlines the legislation requiring the execution of work of an engineering nature in connection with land subdivision.)

PRECISION ECHO SOUNDING IN HYDROGRAPHY. C. B. Potts, *The Canadian Surveyor,* October 1949. (Describes hydrographical and navigational instruments and their use as far back as the 15th and 16th centuries.)

COMMITTEE ON TOPOGRAPHIC MAPPING. Edward B. Rice, *North Carolina Engineer,* October 1949. (Gives a report on the topographic mapping program at the January 1949 meeting in Winston-Salem, N. C.)

THE STORY OF AIDS TO NAVIGATION. Thomas Coulson, *Journal of The Franklin Institute,* October 1949. (Describes the mariner's progress in navigation for 30 centuries.)

AERIAL SURVEY METHODS SOLVE HIGHWAY LOCATION PROBLEMS IN TROPICS. William T. Pryor, *Civil Engineering,* October 1949.

INSTRUCTION IN THE USE OF MAPS NEEDS TO BE INCREASED. Charles W. Saale, *The Journal of Geography,* November 1949. (An outline, in simple terms, for increasing the use of maps and the study of geography in schools at the high school level.)

NEW DISCOVERIES ON THE MID-ATLANTIC RIDGE. Maurice Ewing, *National Geographic Magazine,* November 1949. (Gives an account of the second voyage of exploration of the Mid-Atlantic Ridge.)

SURVEY CAMERA DOES ITS OWN NOTEKEEPING. *Engineering News-Record,* November 24, 1949. (Describes a new invention, called a topographic camera, which is designed to record all sights for later reading in the office.)

NEW TOPOGRAPHIC MAP OF CINCINNATI AND HAMILTON COUNTY, OHIO. Bernard H. Kock, *The Military Engineer,* November–December 1949. (Discusses modern mapping techniques as applied in mapping a city area.)

BOOKS AND PAMPHLETS

TELLING THE STORY OF ENGINEERING RESEARCH. Research Council of the American Society for Engineering Education. *State University of Iowa,* Iowa City. 1949. 52 pages. 50 cents. (Consists of addresses by seven well-known editors and science writers.)

GEODETIC PROBLEMS IN SHORAN (Geodetic Survey of Canada Publication No. 76). J. E. R. Ross. *Department of Mines and Resources,* Ottawa, Canada. 1949. 90 pages. $2.00. (Fundamental principles in the operation of Shoran for triangulation work are discussed, and extensive tables are given based on Clarke's 1866 Spheroid.)

AN INTRODUCTION TO THE STUDY OF MAP PROJECTIONS. J. A. Steers. *University of London Press,* London. 1949. Seventh Edition. 298 pages. 18s. (Gives an account of the Ordnance Survey maps and projections and their postwar program of remapping.)

GEOLOGY: PRINCIPLES AND PROCESSES. William H. Emmons and others. *McGraw-Hill Book Co.,* New York and London. 1949. Third Edition. 502 pages. $4.50.

INTERNATIONAL CARTOGRAPHY. Comite national francais de geographie and the Union geographique internationale. Bibliographie cartographique internationale, 1946, 1947. *Armand Colin,* Paris. 1949. 500 fr. frs. (Compares the cartographical production of eight European states and their dependent territories overseas.)

HANDBOOK OF SCIENTIFIC AND TECHNICAL SOCIETIES AND INSTITUTIONS. Sponsored jointly by National Research Council and Canadian Research Council. *National Academy of Sciences,* Washington, D. C. 1949. 371 pages. $5.00. (Data for 1,302 engineering and scientific organizations in the United States and 166 in Canada are included in the publication.)

MANUAL OF SURVEYING INSTRUMENTS. *W. & L. E. Gurley,* Troy, N. Y. 1949. 166 pages. $1.00. (This 51st edition combines specific details of adjustment of Gurley instruments with related factual information and practical instruction data on the care and handling of all surveying instruments.)

OCCUPATIONAL OUTLOOK HANDBOOK. *U. S. Government Printing Office,* Washington, D. C. 1949. 453 pages. $1.75. (Chances of a job, qualifications and

training required, experience, pay, and other factors are discussed for 288 professional, sub-professional, administrative, clerical, and other occupations.)

SUBSURFACE GEOLOGIC METHODS. L. W. LeRoy and Harry M. Crain. *Colorado School of Mines.* 1949. 826 pages. $6.00. (A compilation of all the various subsurface geologic methods known at the present time.)

GEOLOGY FOR ENGINEERS. Joseph M. Trefethen. *D. Van Nostrand Company, Inc.* 1949. 620 pages. $5.75. (Presents certain fundamentals of geology including the geologic interpretation of topographic maps.)

FUNDAMENTAL TABLES FOR THE DEFLECTION OF THE VERTICAL (Special Publication No. 243). U. S. Coast and Geodetic Survey, Frederic W. Darling. *U. S. Government Printing Office,* Washington, D. C. 1949. 20 cents. (These tables of the Cassinis type provide a means of testing the consequences of density variations and of differing definitions of isostasy.)

MAGNETIC POLES AND THE COMPASS (Serial 726). H. Herbert Howe. *U. S. Coast and Geodetic Survey,* Washington, D. C. 1949. (Clears up certain fallacies with regard to the magnetic poles and to secular change.)

TIDE AND CURRENT GLOSSARY (Special Publication No. 228, U. S. Coast and Geodetic Survey). *U. S. Government Printing Office,* Washington, D. C. 1949. 15 cents. (This publication provides definitions and descriptions of terms applicable to the tide and current work of the Coast and Geodetic Survey.)

—A. A. STANLEY

DISTINCTIVE RECENT MAPS

International Oil is the title of a world map copyrighted in 1948 by the Petroleum Publishing Company of Tulsa, Oklahoma. It was compiled and drawn by the editorial staff of *The Oil and Gas Journal* and issued as a supplement to the December 20, 1948 number of that magazine. The map shows oil fields, oil and gas pipe lines, refineries, and major international trade routes. Tables give "Oil producing fields of the world" and a "Summary of world refinery capacity." There are enlarged insets of Venezuela and the Middle East. The map sheet measures 33 by 44½ inches, including marginal data. No scale is given. The map is on the Mercator projection, but grid lines are omitted.

The ABC Airways Guide Map of the World pictures the air transportation network of the globe. It is copyrighted by Thomas Skinner and Company (publishers of the ABC World Airways Guide) and was prepared by Index Publishers, Ltd., of Dunstable, Bedfordshire, England. Air routes are numbered on the map and indexed to a "Key to Operators of Routes" on the margins. Enlarged insets show Eastern United States, West Indies, and Central America. The map is on the Mollweide Projection, with an approximate scale of 1 : 25,000,000. It is on a sheet which measures 29 by 60 inches.

The International Postal Union published in 1949 two new communication maps of the world. They are entitled *Carte des Lignes Aeropostales* and *Carte des Communications Postales Internationales de Surface.* Both maps were printed at Berne, Switzerland, by Kümmerly and Frey. They are at the scale of 1 : 32,000,000 and measure 32 by 50 inches. The Van der Grinten projection is used. Enlarged insets on both maps show in detail areas of concentration of lines.

A new *Map of Poland and Adjacent Countries* has recently been acquired by the Library of Congress. The map shows generalized relief by orographical coloring and is at the scale of 1 : 1,100,000. The measurements within the border of the map are 37 by 35

inches. It was edited by Dr. B. Zaborski and compiled in the Geographical Section of the Polish Ministry of Information, London, 1944. Publication in 1948 was under the auspices of the Association of Polish University Professors and Lecturers in Great Britain. George Philip and Son of London is the printer.

De facto boundaries and administrative divisions of Poland are shown on *Rceczpospolita Polska, Mapa administracyjna,* published in 1949 by Opracowal Henryk Cytowski. It is 26 by 32 inches and the scale is 1 : 1,000,000.

Another interesting Polish item is the *Railroad Map of Poland* (Siec Kolejowa) published by the Ministry of Transport at Warsaw in 1948. The railroad network is superimposed on a color-layered relief map. An enlarged inset shows the rail net around Katowice. Several graphs indicate the status of "war damage and rebuilding of railway equipment." The map measures 15 by 18 inches and is at the scale of 1 : 2,000,000.

France is divided into geographic regions on the map entitled *Régions Géographiques de la France,* published in 1947 by the Institut National de la Statistique et des Etudes Économiques, Ministère de l'Economie Nationale. "Grande," "Moyenne," "Petite," and "Sous"—divisions are differentiated. The map is printed on six sheets each measuring 25½ by 37 inches; the scale is 1 : 600,000. "This map was prepared for the purpose of making a division of France in geographic regions formed by grouping communes, on the basis of various statistical studies." Reference to this map is made in George Chabot's "Un essai de division de la France en regions geographiques," published in the January–March, 1949 number of *Annales de Geographie* [pp. 51–53].

Germany, Provisional Boundaries of Länder as of January 1947 is the title of a map recently issued by the Civil Administration Division, Government Structures Branch, Office of Military Government United States (OMGUS). The map also shows 1937 international boundaries, 1941 länder boundaries, and province and district boundaries. The map measures 22 by 24 inches and is at the approximate scale of 1 : 1,600,000.

Kak:s Översiktskarta is the title of a new [1949] road map of Sweden, published by the Generalstabens Litografiska Anstalt of Stockholm. It is at the scale of 1 : 1,500,000 and measures 41 by 18 inches. Relief is indicated by hill shading. Although roads are the dominant cultural features shown, the map also includes railroads, ferry or boat connections, cities and towns, and political boundaries. A table of distances between major populated places comprises part of the legend. The map was prepared for the Royal Swedish Automobile Club under the editorship of Fil. dr. Carl M:son Mannerfelt.

Two maps showing population shifts in Great Britain were published in 1948 by the Director General, Ordnance Survey. They are entitled *Population Total Changes 1921–1931* and *Population Total Changes 1931–1939.* The maps are at the scale of 1 : 625,000 and are printed on two sheets, each measuring 32 by 40 inches. Enlarged insets on each map show the London Area.

The maps were compiled by the Ministry of Town and Country Planning. Population changes are shown for each borough and county district as constituted in 1931 and 1939. Color tints are used to show the net changes in population resulting from births, deaths, and migration for the periods covered by the maps.

The University of Coimbra, Centro de Estudos Geográficos, published in 1948 a new population density map of Portugal (*Densidade da População por Freguesias 1940*). It measures 46 by 29 inches and is at the scale of 1 : 500,000. Densities are indicated by 10 color gradations ranging from "1 to 25" to "more than 10,000 persons per square kilometre." Surface geology, soil, annual rainfall, and forest types of Portugal are shown

on small inset maps. The population density map was prepared by Aristides de Amorim Girão, with the collaboration of Fernanda Lopes Velho, Alfredo Fernandes Martins, and Amilcar Augusto Patricio.

Landforms and landtypes of the Island of Cuba are shown in a new combination of color and physiographic sketching on a map prepared by Gerardo Canet with the collaboration of Erwin Raisz. It is entitled *Mapa de los Paisajes de Cuba,* and is at the scale of 1:750,000. The measurements are 21 by 58 inches. An inset map shows Habana and environs in greater detail. A series of eight small colored sketches pictures representative landscapes.

The map is described by the cartographers as "a new experiment in cartography." "The color," they note, "suggests land types: cultivated fields, pastures, mountains, swamps, valleys, etc. The symbols were selected after a series of flights over the Island and an analysis of numerous color photographs taken from the air. It is expected that in this way the map will better reflect reality, more closely resembling an air view of the Island than the conventional maps we now have."

The map of Cuba was prepared to accompany the *Atlas de Cuba* by Canet and Raisz. The atlas was prepared in the Institute of Geographical Exploration at Harvard and published in 1949 by the Harvard University Press in cooperation with the Cuban Ministry of Agriculture.

The *Map of Liberia 1947,* prepared and published by Arthur Sherman in 1948, adds new cartographic data for this African republic. It is based on reconnaissance surveys done in conjunction with mineralogical investigations carried on between 1941 and 1944. Motor roads, trails, railroads, cities and towns, boundaries, rivers and swamps, and generalized mountain ranges are shown on the map. It is at the scale of 1:600,000 and measures 37 by 31 inches.

That part of the United States lying south of Lakes Michigan and Erie and between the Middle Atlantic seaboard and the State of Illinois is included on the map entitled *Natural Resources in the Territory Served by American Gas and Electric Company System.* It was published March 1, 1949, and is based on "geological data compiled from state and United States Geological Survey maps and other publications." Power plants and substations, transmission lines, railroads, navigable rivers, and locations of various mineral deposits are shown. The map measures 20 by 30 inches and is at the scale of 1:1,750,000. There are illustrations and text on the verso of the map. It was printed by Baker, Jones, Hausauer, Inc., of Buffalo, New York.

Land Status Utah is the title of a map published in June 1949 by the Soil Conservation Service, U. S. Department of Agriculture. Generalized areas are indicated, in contrasting colors, for state, Indian, private, and railroad lands, as well as National Forests, National Parks and Monuments, Federal Range, Public Domain, Military Reservations, U. S. purchases, and "Other Federal Land." The map measures 21 by 17 inches and is at the scale of 1:1,100,000. It was compiled in 1940 from various source materials.

The Soil Conservation Service, U. S. Department of Agriculture, published in July 1949 a map showing *Soil Conservation Districts* of the United States. Contrasting colors differentiate districts organized "Prior to 1941," "1941 through 1943," "1944 through 1946," and "Subsequent to 1946." The scale of the map is 1:9,000,000 and the size 12½ by 20 inches.

The Arctic Regions are shown in considerable detail on Sheets ¼ of the *Carte Générale du Monde,* prepared by the Institut Geographique National, [French] Ministère des Travaux Publics et des Transports. Sheet 3 was published in 1947, and sheets 1, 2, and 4

carry a 1948 date. Land relief is indicated by contours and hypsometric tints, and ocean depths by bathymetric lines. Routes of various polar expeditions are traced with red lines. Other information indicated includes railroads, roads, rivers and canals, political boundaries, limit of tree growth, the Magnetic Pole, and centers of habitation. The polar stereographic projection is used, with varying scales at different latitudes. At the Pole the scale is 1 : 3,179,400, and at 65 degrees N. it is 1 : 3,028,000. Each of the four sheets of the *Regions Artiques* measures 37 × 27 inches.

Interest in Antarctica is widespread at the present time, and a number of new maps and charts of the region have been prepared by various governments. Latest to reach the Library of Congress is the *South Polar Chart* (B. A. No. 1240), published at the [British] Admiralty, April 22, 1949, under the Superintendence of Vice Admiral A.G.N. Wyatt, C.B., Hydrographer. It bears the notation "compiled from the latest information in the Hydrographic Department, 1949." Extensive soundings (in fathoms) are given for the oceans surrounding the South Polar land mass. The known portions of the coastline of the Antarctic Continent are sketched in, and the explored areas indicated by shading. The chart measures 25 by 39 inches, and is at the scale 1 : 11,182,000 (at latitude 90° S.). It is laid out on the polar stereographic projection.

—Walter W. Ristow

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New Type of Plat Book

The Boothe Company of San Antonio, Texas, has recently patented a new form of plat book which utilizes aerial photographs overlaid with a closely registering property line diagram.

The first step is the construction of the base, which consists of a controlled mosaic, laid from prints that have previously had tip, tilt, distortion, and other discrepancies removed through the use of the Kargl Rectifier.

With the base completed, the Company obtains the data on property lines and ownership from the county records. These are carefully superimposed on a sheet of acetate in the exact scale of the mosaic, after which they are photographed and worked into a film positive.

The final step is placing the overlay over the mosaic base in exact register, with the result that the property lines may be correlated immediately with a perfect image of the ground.

The working detail scale in most areas is 1 inch = 1,000 feet. The reproduction scale for an entire county or area is 1 inch = 2,000 feet. Towns or cities are usually worked up at scales of 1 inch = 100 feet, with the reproduction on 1 inch = 200 feet.

For anyone who deals with property owners on a large scale, the Boothe Plat Book Arrangement supplies in a moment the information it might otherwise take months to obtain.

Books in Review

MAPS AND MAP-MAKERS. R. V. Tooley. *B. T. Batsford, Ltd.*, London. 1949. Illustrated.

Reviewed by BARRY N. FLOYD, Johns Hopkins University.

THE SUBJECT of historical cartography has given rise to an extensive literature in recent times, though it is true to say that a large part of this output has been rather specialized. To complicate matters, most of the material is widely scattered in the publications of various societies and these are not normally read by the general public. Thus, until 1949, no work had appeared—at least in English—which attempted to deal with the whole subject within the confines of a single book. Then suddenly, and almost simultaneously, two such books appeared, one from each side of the Atlantic.

It is interesting to note that both have laid claim to being the first to have fulfilled this long-felt want. The resumé on the jacket of Mr. R. V. Tooley's book, *Maps and Map-Makers,* published in England, asserts that it is the only book of its kind in existence, while in the introduction to *The Story of Maps* by Mr. Lloyd A. Brown, published in America, the author writes, "This is the story of maps: the men who made them and the methods they employed, what can be found on them and the devious ways in which the information required for their compilation was obtained. There is no other such chronicle in print. . . ."

Since this purports to be a book review on Mr. Tooley's contribution to the history of maps, and since one is also reminded that comparisons are usually odious, this is as far as we shall contrast the two works, save to suggest that, while both professedly have been written on the same subject and with a similar purpose, they are nevertheless widely different in content. The American book is a well-developed treatment of the science and philosophy behind cartographic trends throughout the ages, while the British one is a brief though extremely precise survey of the important map-makers at different periods in history, together with details as to their more noteworthy products.

In other words, Mr. Tooley has attempted to trace the history of maps chiefly through the achievements of the great schools of cartographers in different countries. There are chapters dealing with the maps of Arabs, Italians, French, Dutch, and English, and included in each are lists giving the most important maps of each country and their dates. In the case of England, the author has gone into rather greater detail, with sections on County Maps, Marine Atlases, Large-Scale Maps, and County Atlases.

It is the very briefness and preciseness, and the almost mechanical way in which the chronology of cartography is traced, that makes Mr. Tooley's book, at first sight, disappointing. The author is a man who is widely read in the history of cartography, and who is extensively familiar with old maps. But in this process of learning, Mr. Tooley appears to have lost sight of the elemental propositions of cartography. The problems of representing the curved surface of the earth upon a flat piece of parchment or paper, and depicting three-dimensional topography upon two-dimensional media, are not even hinted at. *Maps and Map-Makers* claims to be a general study, not a specialized one, yet no attempt has been made to signify to the layman the difficulties which confronted men when they first commenced to make maps. The reader who is new to cartography is not easily able to rid himself of the modern mapping concepts so as to be in a position to fully appreciate the achievements typified by earlier mapping efforts.

The book seems to be a series of outline biographies, while the lists of map ascribed to different cartographers and countries do little to modify this summary judgment. The map-illustrations are, however, the book's saving grace. If the reader finds the printed lists tedious and the text dull, then the map-reproductions will certainly suffice to renew interest. They are an enhancing feature of outstanding value, being over 100 in number and including 8 color plates, numerous half-tone reproductions, and a selection in line of

decorative cartouches, scales, ornaments, etc. Such bounteous and attractive illustration, one ventures to suggest, is sufficient reason in itself for purchasing this book.

From the viewpoint of the established collector of maps, of course, Mr. Tooley has performed a useful service. His annotated references almost resemble a catalogue. In this respect, the author's avowed purpose of promoting the collection of maps as a hobby, on the lines of, let us say, stamp collecting, is also successfully accomplished. Furthermore, on re-reading the text, one begins to realize what a wealth of information has gone into *Maps and Map-Makers,* and just how much research the book must have necessitated.

In fact, Mr. Tooley's aim is the clearer in direct proportion to an increased familiarity with the book. Doubtless a more "popular" description of the development of map-making and its relationship to voyages of discovery, exploration, and commercial expansion would have made a more readable work. But to serve the dual aim of interesting a newcomer on the one hand and acting as a guide to the experienced student and collector on the other, one can only arrive at the conclusion that the author has succeeded "as well as can be expected."

COSMOPOLITAN WORLD ATLAS, *Rand McNally & Co.*, Chicago, Ill. 1949. 352 pages. $12.50.

Reviewed by Dr. Helen M. Strong

THE *Cosmopolitan World Atlas,* published by Rand McNally & Co., which was the winner of the Carey-Thomas Award for the best example of creative publishing in 1949, sets a new pattern for American atlases. It skilfully uses cartographic media in presenting significant facts. The atlas is keyed to the present world outlook of America and to the atlas needs of the average American. Relative location and area are indicated in the continental map sequences, in the "thumbnail" index maps, in the facing-page maps, and in the Polar and other regional maps. For example, the facing maps of the Atlantic and Pacific Oceans, through discriminating choice of map projections, are presented on nearly the same scale. Important islands appear in groups and singly. Large-scale insets show important city and other areas. Textual material covers subjects of public interest such as twentieth century changes in the political map of the world; tabular summaries of political and economic information; air, rail, and road distance tables and maps; statistical data for cities and other features. A historical gazetteer of geological names and the 173-page index make place location easy. In short, this atlas brings the best in cartographic and geographic thinking to the service of the American reader.

CONGRESS NEWS

Reports of Technical Divisions

CONTROL SURVEYS DIVISION

At a meeting of the Board of Directors, held on February 3, 1950, Professor W. O. Byrd, of the Ohio State University, was appointed as an Associate Editor of the Division, and Mr. C. A. Whitten, of the U. S. Coast and Geodetic Survey, was appointed as Secretary of the Division.

CARTOGRAPHY DIVISION

The Board of Direction of the Congress approved the Cartography Division By-Laws at their meeting on December 12, 1949. Chairman Crump called the first meeting of the officers and directors of the Division on January 5, at which time he reviewed the activities of the Board of Direction since the last annual meeting, particularly as they affect the Cartography Division. Certain officers and committee chairmen were selected at the initial meeting, and recommendations were submitted for filling vacancies in the chairmanships of various committees.

Three meetings have been held since the initial meeting, resulting in completion of the organization of the Division and in agreements as to the scope, functions, and responsibilities of the standing committees. Much consideration has been given to the type of program the Division will present at the Tenth Anniversary Meeting to be held June 21–23. Sufficient progress has been made to assure a most interesting and informative program. Plans are also being formulated for local meetings to be held in Washington in October and February.

The following committee chairmen were selected:

G. L. Littlepage, U. S. Coast and Geodetic Survey, *Membership*
J. R. Dickens, Hydrographic Office, *Technical Standards*
A. Matterazzi, Aeronautical Chart Service, *Research and Development*
W. E. Davies, U. S. Geological Survey, *Program*
Robert Moravetz, U. S. Geological Survey, *Nominating*

The names of officers and directors of the Division were published in the July–September 1949 issue of SURVEYING AND MAPPING.

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UNIVERSITY OF FLORIDA SURVEYING AND MAPPING CONFERENCE

A Surveying and Mapping Conference, sponsored by the Civil Engineer Section of the Engineering and Industrial Experiment Station, College of Engineering of the University of Florida, was held at Gainesville on October 6 and 7, 1949. The meeting was well attended and the many excellent papers included discussions of city, state and Federal surveying and mapping activities, coordinate systems, and the latest developments in technological and scientific aids to the professions.

CASPER MARSHALL DURGIN

CAPTAIN CASPER M. DURGIN, Chief, Division of Charts, U. S. Coast and Geodetic Survey, died at Suburban Hospital, Bethesda, Maryland, within a few hours after suffering a heart attack on March 11, 1950.

Captain Durgin was born in Exeter, N. H., in 1896. He received his preparatory school education at Phillips Exeter Academy and his engineering degree at Harvard. After graduation he joined the Coast and Geodetic Survey, where he devoted his entire professional career of more than 32 years to surveying, mapping, charting, and related engineering activities.

His early field assignments included geodetic surveying operations in many sections of the United States. The excellent control schemes he designed and executed along the South Atlantic coast are outstanding examples of the advantages of multi-purpose area triangulation as contrasted with single-purpose arc triangulation. An unusual control project assigned to him was that of a first-order traverse along the International Boundary, carried over the ice on the lakes between Minnesota and Canada, often at temperatures of 40 degrees below zero.

His later field assignments included the command of survey ships engaged on topographic, hydrographic, tidal, and current surveys in the coastal waters of the United States, Alaska, and the Philippine Islands. For 2 years during World War II he was detailed as Liaison Officer with the Navy in the Aleutians. This duty included planning for emergency hydrographic surveys and investigations by Coast and Geodetic Survey ships, generally under extremely adverse conditions and on occasions immediately in advance of troop-landing operations.

Captain Durgin was ordered to his first administrative post in Washington in 1934 as Chief of the Aeronautical Chart Section. Under his direction special compilation and drafting units were organized and trained to accelerate the aeronautical charting program. Within a year or so the series of 87 sectional charts was completed and this constituted the first full coverage of the country with aeronautical charts. It is a tribute to his foresight and judgment that this series of charts, substantially in original form as regards size, scale, projection, gradient tints, etc., remains today as the basic series of the United States.

In 1945, Captain Durgin was recalled from the Aleutian Islands to serve as Assistant Chief, Division of Charts, and the following year was made Chief of the Division. He rendered outstanding service in these positions, which carry the responsibility for the compilation, reproduction, and distribution of millions of nautical and aeronautical charts annually. Despite the pressure on his Division, Captain Durgin was always cheerful and anxious to cooperate. Fortunately, he had an unusually keen sense of humor and his vast reservoir of appropriate stories and wise sayings could be depended upon to come to the aid of any situation.

In the passing of Captain Durgin the American Congress on Surveying and Mapping has lost a member whose personal opinions and official work contributed to the attainment of the objectives of the Society.

—FRANK S. BORDEN

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FEDERAL SURVEYS AND MAPS—ACCOMPLISHMENTS 1949

The U. S. Geological Survey has just issued an exceedingly well-prepared and useful report, "Federal Surveys and Maps—Accomplishments During 1949." Such reports covering individual agencies have from time to time been issued during the past, but this is the first time that all the Federal agencies that produce maps have been included in a single treatise.

The activties of each of the 35 Government mapping bureaus are treated separately and in fairly complete detail. Not only is the scope of their field work discussed, but their various map items published or extended during the year are also included.

This report should be welcomed by libraries, educational, commercial, and industrial organizations as well as by the general public. The question of which Federal office should be contacted for a specific or special map is answered here for the first time.

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